DOCUMENT RESUME

ED 201 840 CE 028 908

TITLE	Wastewater Treatment I. Student's Guide.
INSTITUTION	American Water Works Association, Denver, Colo. California - Nevada Section.; California Water Pollution Control Association, Sacramento. Joint Education Committee.; Contra Costa Coll., San Pablo, Calif.
SPONS AGENCY	California Community Colleges, Sacramento.; Office of Education (DHEW), Washington, D.C.
PUB DATE	79
NOTE	215p.; For a related document see CE 028 907. Prepared in collaboration with Remcon, Inc.
EDRS PRICE	MF01/PC09 Plus Postage.
DESCRIPTORS	Behavioral Objectives; Continuing Education; *Equipment Maintenance; *Facilities; Instructional Materials; *Job Skills; Learning Activities; Postsecondary Education; *Vocational Education; *Waste Disposal; Wastes; Water Pollution
IDENTIFIERS	*Waste Water Treatment

ABSTRACT

This student's guide is designed to provide students with the job skills necessary for the safe and effective operation and maintenance of wastewater treatment plants. It consists of three sections. Section 1 consists of an introductory note outlining course objectives and the format of the guide. A course outline constitutes the second section. Section 3 (the bulk of the guide) presents lesson outlines, reviews, and labs (in the form of field trips to wastewater treatment plants) for use in conjunction with the ten chapters of the text entitled "Operation of Wastewater Treatment Plants." Topics covered in these outlines are treatment plant operation; reasons for treating wastes; wastewater facilities; racks, screens, comminutors, and grit removal; sedimentation and flotation; trickling filters; rotating biological contactors; activated sludge; waste treatment ponds; and disinfection and chlorination. (A related instructor's manual is available separately through ERIC--see note.) (MN)

****
* Reproductions supplied by EDRS are the best that can be made *
* from the original document. *
****

ED201840

WASTEWATER TREATMENT I

STUDENT'S GUIDE

Prepared by

Joint Education Committee
of the
California Water Pollution Control Association
and the
California - Nevada Section, American Water Works Association
in cooperation with
REMCON, INC.
and
Contra Costa Community College
for the
California Community Colleges

1979

CE 028 908

U S DEPARTMENT OF HEALTH, EDUCATION & WELFARE
NATIONAL INSTITUTE OF EDUCATION

THIS DOCUMENT HAS BEEN REPRODUCED EXACTLY AS RECEIVED FROM THE PERSON OR ORGANIZATION ORIGINATING IT. POINTS OF VIEW OR OPINIONS STATED DO NOT NECESSARILY REPRESENT OFFICIAL NATIONAL INSTITUTE OF EDUCATION POSITION OR POLICY

"PERMISSION TO REPRODUCE THIS MATERIAL HAS BEEN GRANTED BY

T. Smith

TO THE EDUCATIONAL RESOURCES INFORMATION CENTER (ERIC)."

LIST OF FIGURES

		PAGE
CHAPTER 2		
Figure 1,	Composition of solids in raw wastewater	15
Figure 2,	Simplified illustration of nitrogen cycle	17
Figure 3,	Typical NPDES permit reporting form	19
CHAPTER 3		
Figure 4,	Flow diagram of Wastewater Treatment Process. . .	24
Figure 4a,	Possible flow pattern through a pond treatment plant	25
Figure 4b,	Possible flow pattern through a trickling filter plant.	26
Figure 4b (Con'd)	Possible flow pattern through a trickling filter plant.	27
Figure 4c,	Possible flow pattern through an activated sludge plant.	28
Figure 4c (Con'd)	Possible flow patterns through an activated sludge plant.	29
Figure 5,	Rectangular clarifier	33
Figure 6,	Circular clarifier.	34
Figure 7,	Trickling filter.	36
Figure 8a,	Possible sludge processing and solids disposal flow pattern (sludge drying beds)	39
Figure 8b,	Possible sludge processing and solids disposal flow pattern (vacuum filtration)	40
Figure 9,	Section of sludge digester.	41
CHAPTER 4		
Figure 10,	Flow diagram of a typical plant	47
CHAPTER 5		
Figure 11,	Flow diagram of a typical plant	64
Figure 12,	Plan diagram of typical clarifiers in a wastewater treatment plant.	65
Figure 13,	Side-view section of a rectangular sedimentation basin	66
Figure 14,	Side-view section of a circular clarifier with blades and scraper squeegees	67

PAGE

Figure 15, Combined sedimentation - digestion unit (Permission of Dorr-Oliver Incorporated) 78

CHAPTER 6 Flow diagram of a typical plant 81

Figure 16

Figure 17, Plan of typical trickling filter plant 82

Figure 18, Trickling filter 83

Figure 19, Trickling filter recirculation patterns 86

CHAPTER 7

Figure 20 Flow diagram of a typical plant 97

Figure 21, Typical rotating biological contractor treatment plant 98

Figure 22, Possible rotating biological contractor layouts 99

CHAPTER 7 or 8

Figure 23, Flow diagram of a typical plant 109

CHAPTER 9

Figure 24, Typical plant; ponds only 139

Figure 25, Typical plant, ponds after secondary treatment. 140

Figure 26, Pond Classifications. 142

Figure 27, Process of decomposition in aerobic and anaerobic layers of a pond. 143

CHAPTER 10

Figure 28 Flow diagram of a typical plant 152

Figure 29, Points of chlorine application. 155

TABLE OF CONTENTS

		PAGE
I.	To the Student	v
II.	Course Outline	xiii
III.	Lesson Outlines	
	Class Procedures	1
	Chapter 1, The Treatment Plant Operator	3
	Lab	6
	Chapter 2, Why Treat Wastes	7
	Lab	21
	Chapter 3, Wastewater Facilities	22
	Lab	45
	Chapter 4, Racks, Screens, Comminutors and Grit Removal	46
	Lab	58
	Review for Exam I, Chapters 1 through 4	59
	Exam I	60
	Exam I, Review Results	61
	Lab	62
	Chapter 5, Sedimentation and Flotation	63
	Lab	79
	Chapter 6, Trickling Filters	80
	Lab	94
	Chapter 7, Rotating Biological Contactors (Second Edition)	95
	Lab	103
	Review for Exam II, Chapter 5 through 7	104
	Exam II	105
	Exam II, Review Results	106
	Lab	107
	Chapter 7, Activated Sludge (First Edition or Chapter 8, Activated Sludge (Second Edition)	108
	Lab	119

PAGE

Lab 129
Lab 137
Chapter 9, Waste Treatment Ponds 138
Lab 150
Chapter 10, Disinfection and Chlorination 151
Lab 161
Review for Exam III, Chapters 9 through 10 164
Exam III 165
Lab 166
Exam III, Review Results 167
Review for Final Exam 168
Lab 169
Final Exam 170

I. TO THE STUDENT

This "Student's Guide" was prepared to help you learn how to safely and effectively operate and maintain wastewater treatment plants while taking the course, Wastewater Treatment I. The general objective of the course is to teach you the knowledge and skills you need to obtain a job and advance in the field of wastewater treatment.

Course objectives as well as objectives for each class meeting are provided in this guide. An outline for each class indicates the important material that should be covered. Each page is divided in half with topics on the left half and ample space on the right half for you to insert your own notes. Your instructor will try to emphasize those specific tasks you will have to perform when you work in a wastewater treatment plant. Where appropriate your instructor probably will adjust the class outline to best meet your needs.

Whether you are an experienced operator taking this course as a refresher or someone who has never worked in a wastewater treatment plant, you will get out of this course what you put into it. Hopefully most of the students will have backgrounds similar to yours so the instruction will be directed to all the students all of the time. If you are new to this field, you may have to make extra visits to wastewater treatment plants in order to visualize the facilities being discussed in class. You may have to ask more questions than anyone in class, but you owe it to yourself to understand the subject matter. If you are an experienced operator, you should feel free to share your experiences with the other students. This may encourage other operators and you will benefit from their experience and ideas. Following successful completion of this course, you should be able to pass the Grade I and probably the Grade II Operator Certification Exams administered by the California State Water Resources Control Board.

The lesson outlines follow the manual, Operation of Wastewater Treatment Plants, prepared by and available from Dr. Kenneth D. Kerri, Professor of Civil Engineering, California State University, Sacramento, 6000 "J" Street, Sacramento, California 95819. The actual material was written by operators of wastewater treatment plants on the basis of what they believe operators need to know to do their jobs. Funds for the development of the manual were provided by the U. S. Environmental Protection Agency in co-operation with the California Water Pollution Control Association. The first edition was published in 1970 and has been updated almost every year when more manuals were printed. The first draft of the second edition has been completed. Where appropriate the outlines will indicate the appropriate sections in both the first and second editions. Table I lists the Chapters in the First Edition and Table II lists the Chapters in the Second Edition.

Table III, List of Performance Tasks, Skills, Knowledge from CCCC (Charles County Community College, La Plata, Maryland) "Job Analysis" Process Control, illustrates the depth of skills and knowledge operators need to know to do their job. This material was developed for the U. S. Environmental Protection Agency to serve as a guide for persons developing training materials. Remember that equipment manufacturers are always attempting to improve their products by developing newer and better equipment. For these reasons operators often must rely on equipment manufacturers for details on how to start up, operate, maintain, repair and shut down complex pieces of equipment.

TABLE I. CHAPTERS IN THE FIRST EDITION OF OPERATION OF WASTEWATER TREATMENT PLANTS

CHAPTER	TOPIC
1.	Introduction
2.	Why Treat Wastes?
3.	Wastewater Facilities
4.	Racks, Screens, Comminutors and Grit Removal
5.	Sedimentation and Flotation
6.	Trickling Filters
7.	Activated Sludge
8.	Sludge Digestion and Handling
9.	Waste Treatment Ponds
10.	Disinfection and Chlorination
11.	Maintenance
12.	Plant Safety and Good Housekeeping
13.	Sampling Receiving Waters
14.	Laboratory Procedures and Chemistry
15.	Basic Mathematics and Treatment Plant Problems
16.	Analysis and Presentation of Data
17.	Records and Report Writing
	Glossary

TABLE II. CHAPTERS IN THE SECOND EDITION OF OPERATION OF WASTEWATER TREATMENT PLANTS

CHAPTER	TOPIC
	VOLUME I
1.	The Treatment Plant Operator
2.	Why Treat Wastes?
3.	Wastewater Treatment Facilities
4.	Racks, Screens, Comminutors and Grit Removal
5.	Sedimentation and Flotation
6.	Trickling Filters
7.	Rotating Biological Contactors
8.	Activated Sludge (Part I. Package Plants and Oxidation Ditches)
9.	Waste Treatment Ponds
10.	Disinfection and Chlorination
	Glossary
	VOLUME II
11.	Activated Sludge (Part II. Conventional Activated Sludge Plants)
12.	Sludge Digestion and Solids Handling
13.	Effluent Disposal
14.	Plant Safety and Good Housekeeping
15.	Maintenance
16.	Laboratory Procedures and Chemistry
17.	Basic Arithmetic and Treatment Plant Problems
18.	Analysis and Presentation of Data
19.	Records and Report Writing
	Glossary

TABLE II. (Con'd)

CHAPTER	TOPIC
	VOLUME III
20.	Odor Control
21.	Activated Sludge (Part III. Pure Oxygen & Operational Control Alternatives)
22.	Solids Handling and Disposal
23.	Solids Removal from Secondary Effluents
24.	Phosphorus Removal
25.	Wastewater Reclamation
26.	Instrumentation
27.	Industrial Waste Monitoring
28.	Industrial Waste Treatment
29.	Support Systems
	Glossary

TABLE III. LIST OF PERFORMANCE TASKS, SKILLS KNOWLEDGE FROM CCCC "JOB ANALYSIS" PROCESS CONTROL

1. Identify the device or equipment.
2. Describe the device or equipment:
   - 2A. Purpose (how it affects the wastestream)
   - 2B. How it affects aeration, digestion, grit removal, primary sedimentation, pumping & piping, solids disposal, trickling filtration, etc
3. Identify the components of a specific device or equipment from (1) above.
4. Describe each component with respect to:
   - 4A. Function (operation and purpose)
   - 4B. Importance of each function
5. Name and locate the components of the device/equipment from (1) above.
6. Describe safety procedures for the device/equipment.
   - 6A. High risk activities
   - 6B. Sources of danger
   - 6C. Safety equipment and purpose
7. Describe the normal operation procedures for each component.
   - 7A. Describe the characteristics of each component to check
   - 7B. Identify normal/abnormal conditions/indicators
   - 7C. Explain how often each component must be checked and why
   - 7D. Describe operator actions required if conditions/indicators are abnormal: adjustments, corrective maintenance, report to supervisor, report in writing
   - 7E. Explain why component's characteristics must be returned to normal
   - 7F. Describe the routine sampling for the device/equipment
   - 7G. Describe the routine calculations for the device/equipment
   - 7H. Describe the routine procedures for recording data
8. Describe the start-up and shut-down procedures for the device/equipment
   - 8A. Describe the start-up procedure
   - 8B. Describe the shut-down procedure
   - 8C. Evaluate whether correct start-up procedures have been used
   - 8D. Evaluate whether correct shut-down procedures have been used

TABLE III. (Con'd)

9. Describe the abnormal operation procedures for the device/ equipment.

   9A. Evaluate the wastestream for abnormal conditions: amount of floating and suspended material, velocity and level of the flow, the waste characteristics, the high and low range of acceptable value for each characteristic
   9B. Describe the cause and effect of the abnormal condition
   9C. Explain how often the condition of the wastestream must be checked
   9D. Describe what an operator does if abnormal conditions observed: operational changes, reporting to supervisor, sampling procedures
   9E. Describe how the actions of the operator will improve the condition of the wastestream

10. Describe the preventive maintenance procedures for the device/ equipment.

   10A. Describe pertinent procedures, such as: cleaning, painting, lubrication, mechanical adjustment, replacement, wear measurement, etc
   10B. Name the reference materials and tools needed for each preventive maintenance procedure in 10A
   10C. Explain how often each preventive maintenance procedure must be performed
   10D. Explain what an operator does if a component needs preventive maintenance
   10E. Explain how an operator determines whether a component needs preventive maintenance
   10F. Explain why each preventive maintenance procedure is important

11. Describe the corrective maintenance procedures for the device/ equipment.

   11A. Describe how an operator evaluates each component for corrective maintenance: capacity, color, corrosion, depth, deterioration, flow, motion, odor, position, sound, temperature, vibration, etc
   11B. Explain why a component has malfunctioned
   11C. Name the reference materials and tools needed to perform the corrective maintenance
   11D. Describe what an operator does when a malfunction is discovered: evaluation of capabilities of plant personnel to perform the procedures, selection of replacement parts, record keeping
   11E. Describe how the operator corrects the malfunction

II. COURSE OUTLINE

WASTEWATER TREATMENT I

WEEK	TOPIC
1.	Class Procedures
	The Treatment Plant Operator
2.	Why Treat Wastes?
3.	Wastewater Treatment Plants
4.	Racks, Screens, Comminutors and Grit Removal
5.	Review, Exam, Return Exam and Critique
6.	Sedimentation and Flotation
7.	Trickling Filters
8.	Rotating Biological Contactors
9.	Review, Exam, Return Exam and Critique
10.	Activated Sludge Process
11.	Package Aeration Plants
12.	Oxidation Ditches
13.	Waste Treatment Ponds
14.	Disinfection
15.	Review, Exam, Return Exam and Critique
16.	Disinfection, Review Course
17.	Final Exam

WASTEWATER TREATMENT II
TENTATIVE COURSE OUTLINE

WEEK	TOPIC
1.	Class Procedures
	Review of Wastewater Treatment I
2.	Activated Sludge
3.	Activated Sludge
4.	Activated Sludge
5.	Review, Exam, Return Exam and Critique
6.	Sludge Digestion and Solids Handling
7.	Sludge Digestion and Solids Handling
8.	Effluent Disposal
9.	Plant Safety and Good Housekeeping
10.	Review, Exam, Return Exam and Critique
11.	Maintenance
12.	Maintenance
13.	Analysis and Presentation of Data
14.	Records and Report Writing
15.	Review, Exam, Return Exam and Critique
16.	Advanced Topics on Activated Sludge and Solids Handling
	Review Course
17.	Final Exam

16

III. LESSON OUTLINES

Week 1	Hour 1	Chapter: Class Procedures

Lesson Outline	Lecture Notes

Objectives: Familiarize students with class procedures, course policy, grading, course objectives and topics covered.

Assignment: Objective test at end of Chapter 1 (due in one week).

Lecture Outline

1. Handouts (adjust example handouts to meet your needs).
    1. Course Policy
    2. Course Outline
2. Call roll. Admit new students
3. Course Objectives
    1. Provide students with the knowledge and skills needed to safely and effectively operate and maintain wastewater treatment plants.
    2. Develop new, qualified treatment plant operators.
    3. Expand abilities of existing operators of treatment plants.
    4. Prepare operators to pass certification examinations.
4. Grading and how final grade determined

Week 1	Hour 1 (Con'd)	Chapter: Class Procedures

Lesson Outline	Lecture Notes
5. Quizzes 6. Homework 7. Missed exams and quizzes 8. Examination procedures 9. Old exams 10. Examination critique 11. Dropping course 12. Final grade (How obtained) 13. Course Outline (See previous outline or handout) 14. Whenever a lesson outline for an hour is completed, continue with the next hour if time permits.	

CHAPTER 1

THE TREATMENT PLANT OPERATOR

Week 1	Hour 2	Chapter: 1 The Treatment Plant Operator

Lesson Outline

Objective: Describe duties of an operator and job opportunities.

Lecture Outline

1.0 What is a treatment plant operator?

1.1 Your personal training program.

1.2 What do you already know?

1.3 The water quality protector: YOU

1.4 Your qualifications.

1.5 Manpower needs and future job opportunities.

1. How to obtain jobs at local treatment plants. Persons to contact:

Name_____

Address_____

Phone Number_____

2. Job opportunities_____

3. Starting & future salaries_____

1.6 Training yourself to meet the needs.

1. Operator publications

a. Water Pollution Control Federation Deeds & Data

b. California Water Pollution Control Association Bulletin

Lecture Notes

Week 1	Hour 2 (Con'd) Chapter: 1 The Treatment Plant Operator
Lesson Outline	**Lecture Notes**
2. California Water Pollution Control Association training conferences, short schools and workshops.	

Week 1	Hour 3	Chapter: 1 The Treatment Plant Operator

Lesson Outline	Lecture Notes
Objective: Determine how to qualify, apply and pass operator certification exams. Lecture Outline 1. Types of plants requiring various levels of certification. 2. Qualifications necessary to apply for certification exams. 3. How to apply for certification exams. 4. How to study for certification exams. 5. Typical types of exam questions. 6. Comments by students who have taken exams.	

Week 1	3- Hour Lab (Optional)	Chapter: 1 The Treatment Plant Operator

Lesson Outline	Lecture Notes
Objectives: Visit a wastewater treatment plant and become familiar with the flow paths of water and solids. Assignment: 1. Describe purpose of each treatment process and how it works. 2. Prepare a list of tasks done by operators.	

CHAPTER 2

WHY TREAT WASTES?

Week 2	Hour 1	Chapter: 2 Why Treat Wastes?

Lesson Outline	Lecture Notes
Objective: Describe characteristics of wastes and why wastewater must be treated. NOTE: Outline for Week 2 may be condensed into one hour if instructor and students are anxious to devote their time in the actual operation of treatment plants. Assignment: Objective test at end of Chapter 2. Lecture Outline Pronunciation Guide Glossary: Discuss new words 2.0 Prevention of Pollution 1. Protect public health (drinking and swimming) and aquatic life from poisons and diseases (fishing and birds) 2. Protect beneficial uses of water such as municipal and industrial water supplies, irrigation, navigation and recreation. 2.1 What is Pure Water? 1. Distilled water 2. Rain Water 3. Sea water conversion	

Week 2	Hour 1(Con'd)	Chapter: 2 Why Treat Wastes?

Lesson Outline	Lecture Notes
4. Reclaimed wastewater	
2.2 Types of Waste Discharges	
1. Municipal	
2. Industrial	
3. Agricultural runoff	
a. Feed lots and dairies	
b. Irrigation	
4. Storm water runoff	
5. Point and nonpoint sources	
6. Types of wastes	
a. Organic	
b. Inorganic	
c. Thermal	
d. Radioactive	

Week 2	Hour 2	Chapter: 2 Why Treat Wastes?

Lesson Outline

Objective: Describe characteristics of wastes and why wastewater must be treated.

Lecture Outline

2.3 Effects of Waste Discharges

2.30 Sludge and Scum

1. Bottom sludge deposits
   a. Depletion of dissolved oxygen (DO) in stream.
   b. Cover plant life, aquatic organisms; fish food and spawing beds
2. Surface scum
   a. Unsightly (evidence of pollution) scums and floatables
   b. Reduces surface re-aeration and sunlight penetration of water for photosynthesis
3. Both sludge and scum exert a detrimental impact on oxygen resources of a stream or river that are essential for fish life

Lecture Notes

Week 2	Hour 2(Con'd)	Chapter: 2 Why Treat Wastes?

Lesson Outline	Lecture Notes
2.31 Oxygen Depletion 1. Aquatic organisms, including fish, require sufficient dissolved oxygen (DO) in their aquatic environment for survival. 2. Respiration (breathing) removes oxygen (DO) from water. 3. The more food (wastes) in water, the more active (higher respiration and reproduction rates) become the aquatic organisms. If the oxygen supply is not replenished, the aquatic organisms and fish could die from lack of oxygen (just like people) 4. If there is no dissolved oxygen (DO) in water, anaerobic bacteria thrive	

Week 2	Hour 2 (Con'd)	Chapter: 2 Why Treat Wastes?

Lesson Outline

5. Define anaerobic bacteria
6. Anaerobic bacteria decompose wastes and produce undesirable odors (hydrogen sulfide gas, H_2S)
7. Hydrogen sulfide gas is very dangerous.
   a. H_2S smells like rotten eggs. Your nose quickly gets tired of smelling this odor and before long you can no longer detect the presence of hydrogen sulfide gas.
   b. Hydrogen sulfide is a toxic gas that can kill you by paralyzing your respiratory center.
   c. Hydrogen sulfide gas can kill you because it is explosive and flammable
   d. Hydrogen sulfide gas can kill you by accumulating in a confined space

Lecture Notes

Lesson Outline	Lecture Notes
until there is insufficient oxygen in the atmosphere for you to breathe. e. The safety record of people working in the wastewater treatment industry is one of the worst of any industry in the United States. 2.32 Human Health 1. Viruses 2. Diseases 3. Poison or toxic substances 2.33 Other Effects 1. pH a. Define pH b. Impact of high or low pH on aquatic life and industrial water users 2. Toxic substances (impact on aquatic life) a. Heavy metals b. Cyanide c. Chlorine residual in effluent	

Week 2	Hour 2 (Con'd)	Chapter: 2 Why Treat Wastes?

Lesson Outline	Lecture Notes
3. Tastes and odors 4. Nutrients	

Week 2	Hour 3	Chapter: 2 Why Treat Wastes?

Lesson Outline	Lecture Notes
Objective: Describe characteristics of wastes and why wastewater must be treated. Lecture Outline 2.4 Solids in Wastewater Refer to Figure 1, composition of solids in raw wastewater. 2.40 Types of Solids (define and describe terms) 1. Suspended and dissolved solids 2. Organic and inorganic solids 2.41 Total Solids 1. How measured 2. Dissolved and suspended solids 2.42 Dissolved Solids 1. How measured 2. Filterable residue 2.43 Suspended Solids 1. How measured 2. Nonfilterable residue 3. Settleable solids 2.44 Organic and Inorganic Solids 1. Organic solids are of animal or vegetable origin and	

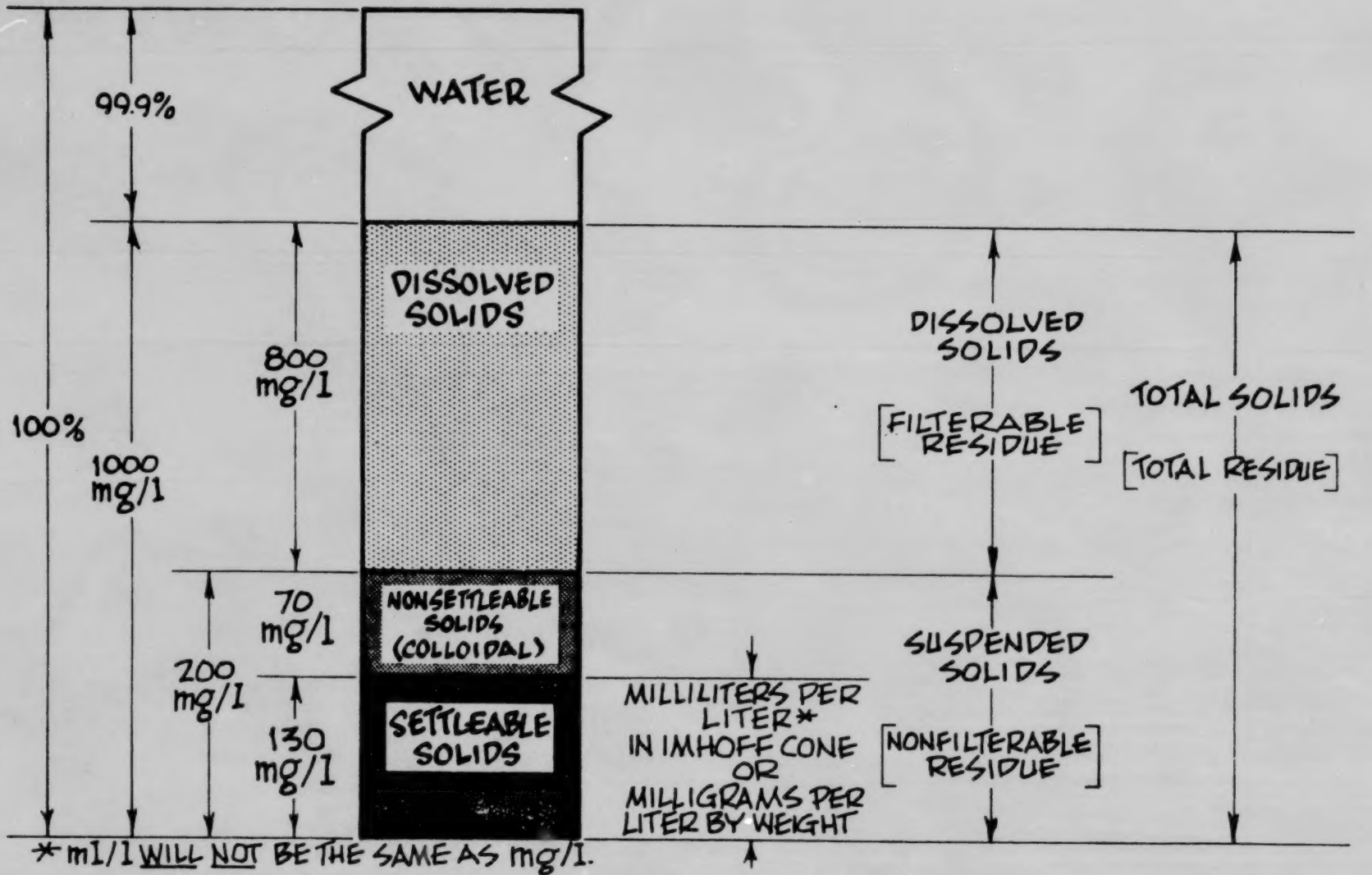
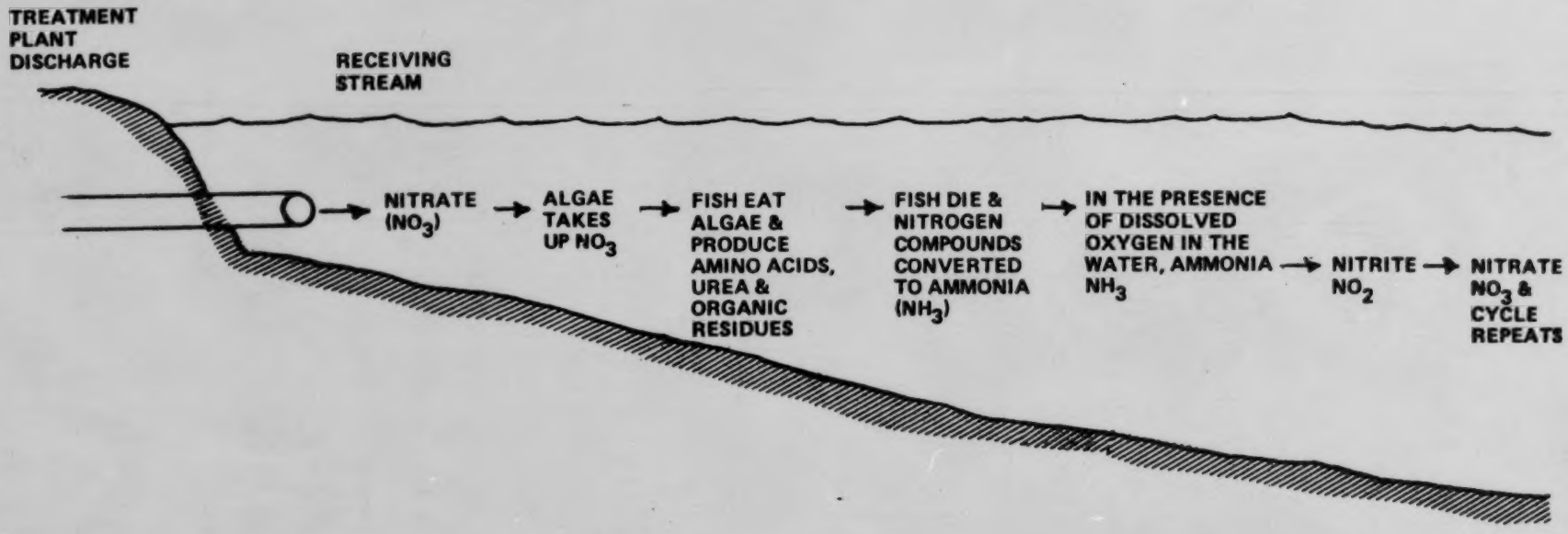


Fig. 1
15

Composition of solids in raw wastewater

Lesson Outline	Lecture Notes
twice provide food for aquatic organisms 2. Inorganic solids are of mineral origin and serve as nutrients for aquatic plants, including algae 2.45 Floatable Solids 2.5 Natural Cycles (Second Edition only) Refer to Figure 2, simplified illustration of nitrogen cycle. 1. Factors influencing damages caused by the discharge of treated wastewaters on receiving waters 2. Natural cycles Natural purification cycle, cycle of water, life cycles of aquatic organisms, and nutrient cycles 3. Nutrient cycles Carbon, hydrogen, oxygen, sulfur, nitrogen and phosphorus 4. Nitrogen cycle a. Refer to Figure 2, simplified illustration of nitrogen cycle on next page.	

Fig. 2
17


TREATMENT PLANT DISCHARGE
RECEIVING STREAM
NITRATE (NO_3)
ALGAE TAKES UP NO_3
FISH EAT ALGAE & PRODUCE AMINO ACIDS, UREA & ORGANIC RESIDUES
FISH DIE & NITROGEN COMPOUNDS CONVERTED TO AMMONIA (NH_3)
IN THE PRESENCE OF DISSOLVED OXYGEN IN THE WATER, AMMONIA NH_3
NITRITE NO_2
NITRATE NO_3 & CYCLE REPEATS

Simplified illustration of nitrogen cycle

Lesson Outline	Lecture Notes
b. Under aerobic conditions (DO present) nitrogen compounds converted to nitrate (NO_3^{-1}, an ion containing oxygen). Other ions created under aerobic conditions include sulfate (SO_4^{-2}) and phosphate (PO_4^{-3}) c. Under anerobic conditions (no DO present) nitrogen compounds converted to ammonium (NH_4^+, an ion containing no oxygen). Other compounds created under anaerobic conditions include hydrogen sulfide (H_2S) and methane (CH_4). 2.6 NPDES Permits (Second Edition only) Refer to Figure 3, Typical NPDES permit reporting form. 1. National Pollutant Discharge Elimination System (NPDES) 2. Water quality indicators specified 3. Monthly average and maximum levels	

MONTHLY OPERATION REPORT OF WASTEWATER TREATMENT FACILITY

STABILIZATION PONDS

NAME OF FACILITY _____

PHONE _____

Send to MINNESOTA POLLUTION CONTROL AGENCY
1935 WEST COUNTY ROAD B 2
ROSEVILLE, MINNESOTA 55113
ATTN COMPLIANCE & ENFORCEMENT SECTION

MONTH _____ , 19 ____ DIS. NO. _____ PERMIT NUMBER _____ NAME OF FACILITY _____

Fig. 3
19

TYPE OF POND (PRIMARY, SECONDARY, AERATED, ETC.)	_____ POND _____ ACRES					_____ POND ___,___ ACRES					_____ POND _____ ACRES				
WEEK OF THE MONTH	1st	2nd	3rd	4th	5th	1st	2nd	3rd	4th	5th	1st	2nd	3rd	4th	5th
1 DATE OF TEST OR OBSERVATION															
2 ODOR (YES OR NO)															
3 AQUATIC PLANTS (% OF COVERAGE, TYPE)															
4 FLOATING MATS (% OF COVERAGE, TYPE)															
5 POND WATER DEPTH (NEAREST INCH)															
6 MUSKRATS, RODENTS ETC (YES OR NO)															
7 DIKE CONDITION (EROSION ETC.)															
8 ICE COVER (% OF COVERAGE)															

GENERAL			ANALYSIS – POND INFLUENT, EFFLUENT																RECEIVING WATERS DATA														
			INFLUENT				EFFLUENT DISCHARGE												ABOVE OUTFALL _____ MILES			BELOW OUTFALL _____ MILES			PRESENT CONDITION								
DATE	9 DAY OF WEEK	10 PRECIPITATION (INCHES)	11 FLOW (MGD)	12 SAMPLE TYPE	13 BOD (mg/l)	14 TSS (mg/l)	15 FLOW (MGD)	16 TIME SAMPLED	17 BOD (mg/l)	18 TSS (mg/l)	19 TURBIDITY (JTU)	20 FECAL COLIFORM (MPN/100 ml)	21 DO (mg/l)	22 pH (standard units)	23 TOTAL PHOSPHORUS AS P (mg/l)	24 KJELDAHL NITROGEN (mg/l)	25 CHLORINE USED (LBS)	26 CHLORINE RESIDUAL (mg/l)	27 TIME OF DAY	28 WATER TEMP °F	29 DO (mg/l)	30 TIME OF DAY	31 WATER TEMP °F	32 DO (mg/l)	DEPTH (ft)	WIDTH (ft)	VELOCITY (ft/sec)	NORMAL +/-	DATE	REMARKS (SEE ITEM 35)
1																													1	
2																													2	
3																													3	
4																													4	
5																													5	
6																													6	
7																													7	
8																													8	
9																													9	
10																													10	
11																													11	
12																													12	
13																													13	
14																													14	
15																													15	
16																													16	
17																													17	
18																													18	
19																													19	
20																													20	
21																													21	
22																													22	
23																													23	
24																													24	
25																													25	
26																													26	
27																													27	
28																													28	
29																													29	
30																													30	
31																													31	
TOTAL																														
MIN. REPORTED VALUE																														
MIN. PERMIT CONDITION																														
AVG. REPORTED VALUE																														
AVG. PERMIT CONDITION																														
MAX. REPORTED VALUE																														
MAX. PERMIT CONDITION																														
REPORTED FREQUENCY OF ANALYSIS																														
PERMIT CONDITION FREQUENCY OF ANALYSIS																														
REPORTED SAMPLE TYPE																														
PERMIT CONDITION SAMPLE TYPE																														

35 REMARKS: INCLUDE BYPASS AND OVERFLOW OCCURRENCES, UNUSUAL SEWAGE OR STREAM FLOW PROBLEMS, OPERATIONAL PROBLEMS, OTHER REQUIRED PARAMETER DATA, COMPLAINTS, ETC. IN SPACES ON BACK OF THIS FORM.

I certify that I am familiar with the information contained in this report and that to the best of my knowledge and belief such information is true, complete, and accurate.

SIGNATURE OF PRINCIPAL EXECUTIVE OFFICER OR AUTHORIZED AGENT _____ DATE _____

MPCA FORM 704

40

Typical NPDES permit

41

Week 2 Hour 3(Con'd) Chapter: 2 Why Treat Wastes?	
Lesson Outline	**Lecture Notes**
4. Review permit reporting form 2.7 Additional reading. Importance of being aware of other publications 2.8 Review 1. Objectives of wastewater treatment: Protect the receiving waters and downstream water users at the lowest possible costs. 2. Methods of accomplishing objectives	

Week 2	3- Hour Lab (Optional)	**Chapter:** 2 Why Treat Wastes?

Lesson Outline	**Lecture Notes**
Objective: Visit a different wastewater treatment plant than the one visited last week and become familiar with the flow paths of water and solids. Assignment: 1. Describe purpose of each treatment process and how it works. 2. Prepare a list of tasks done by the operators.	

CHAPTER 3

WASTEWATER FACILITIES

Week 3	Hour 1	Chapter: 3 Wastewater Facilities

Lesson Outline	Lecture Notes
Objectives: 1. Describe various types of wastewater treatment plants. 2. Draw schematic plan layouts of typical plants. 3. List major treatment processes and the purpose of each process. Assignment: Objective test at end of Chapter 3 plus objectives 2 and 3 listed above. Lecture Outline: Glossary: Review new words 3.0 Collection, Treatment and Disposal 3.1 Collection of Wastewater 1. Pipes and pumps 2. Waste discharges a. Flows b. Waste characteristics 3. Impact of collection and transportation on wastewater characteristics and flows 4. Impact of stoppages and activities of sewer maintenance crews on wastewater characteristics and flows.	

Lesson Outline	Lecture Notes
3.10 Sanitary, Storm and Combined Sewers 1. Sanitary sewers 2. Storm sewers 3. Combined sewers 4. Infiltration 3.2 Treatment Plants Refer to Fig. 4, Flow diagram of wastewater treatment processes 1. Discuss treatment processes and functions 2. Ponds (Fig. 4.a) 3. Trickling Filters (Fig. 4.b) 4. Activated Sludge (Fig. 4.c) 3.3 Pretreatment 3.30 Purpose Separate coarse material from water being treated 3.31 Screening Bar screens (manually cleaned and mechanically cleaned)	

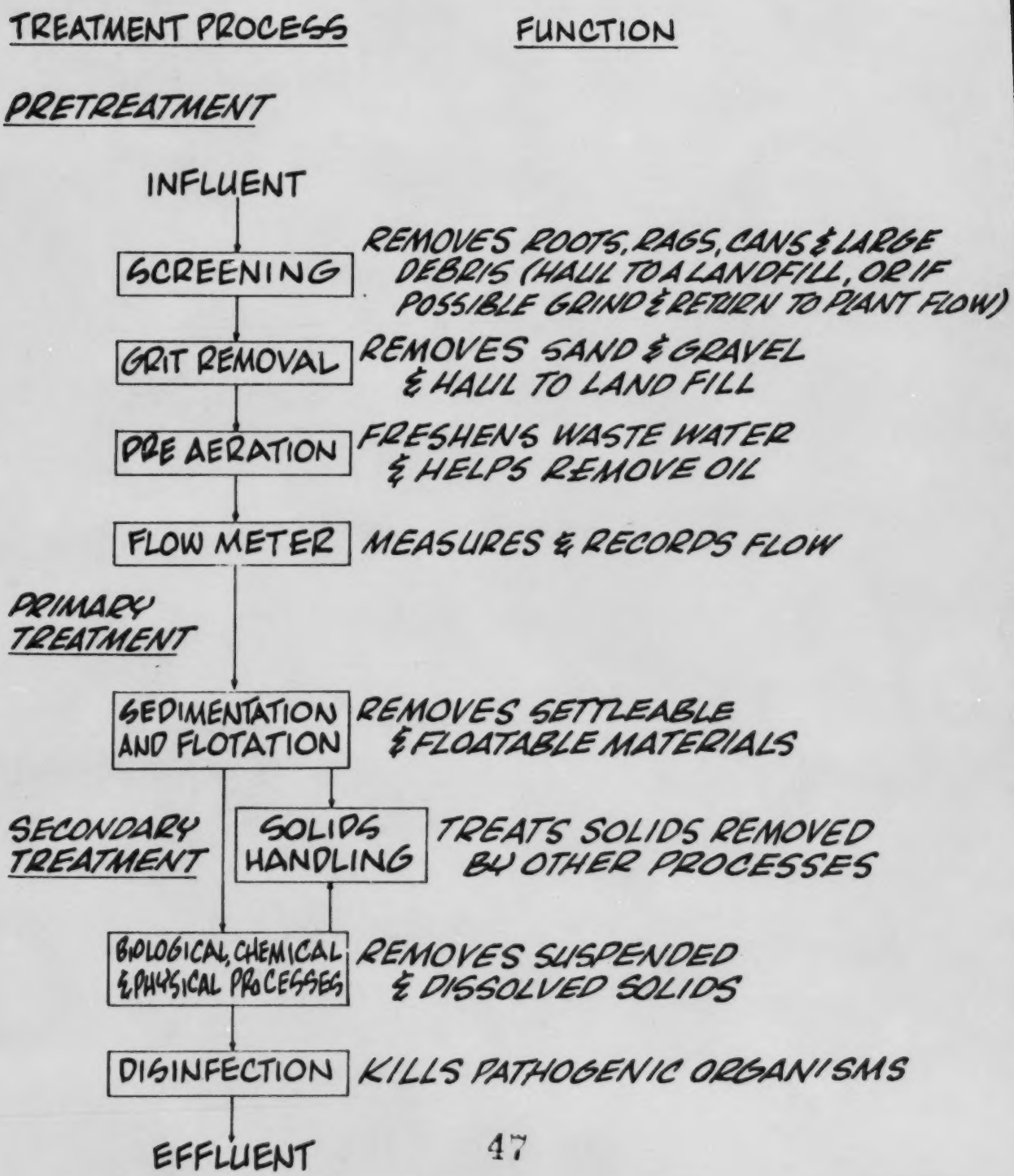


Fig. 4 Flow Diagram of Wastewater Treatment Processes

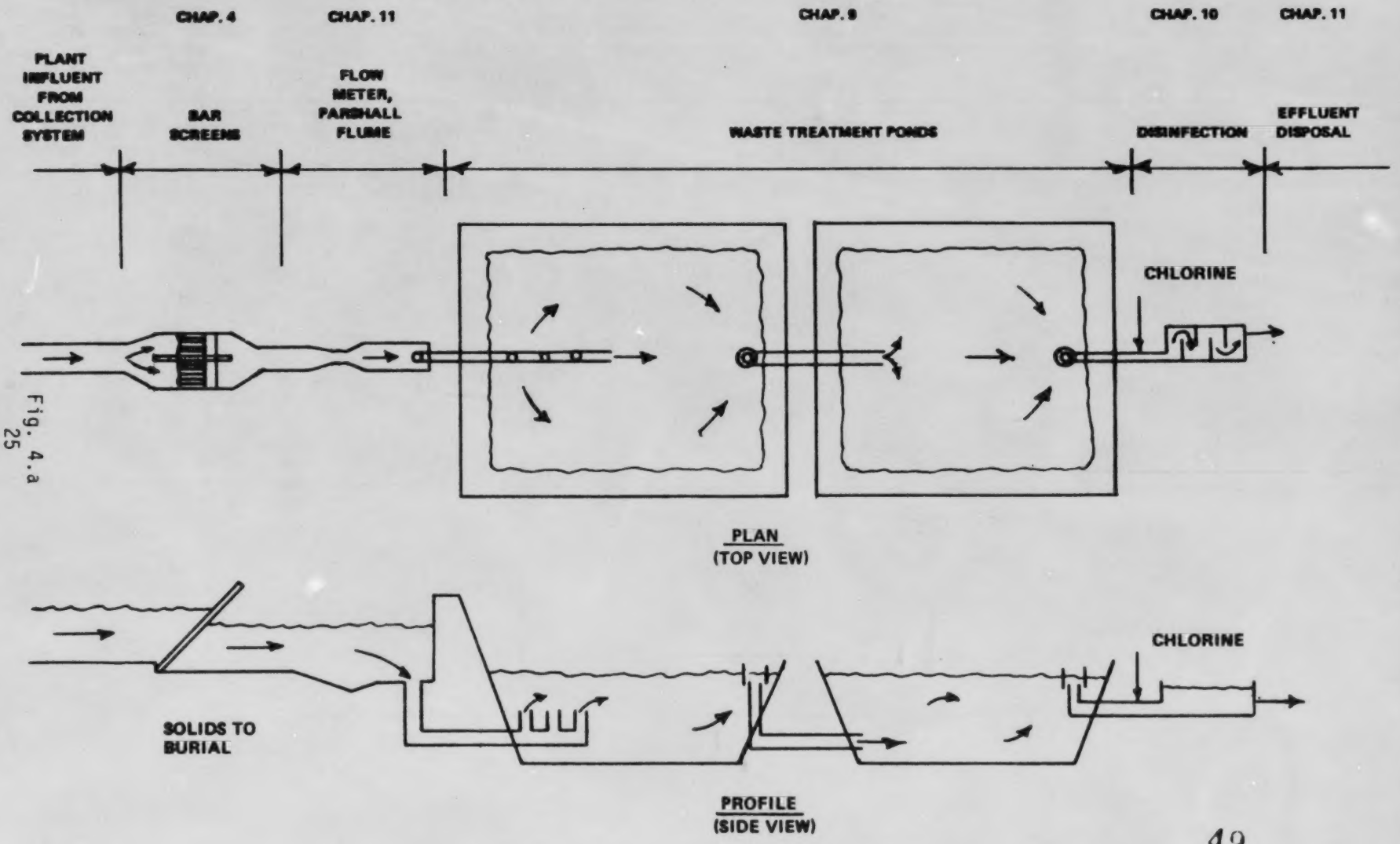


Fig. 4.a
25

Possible flow pattern through a pond treatment plant

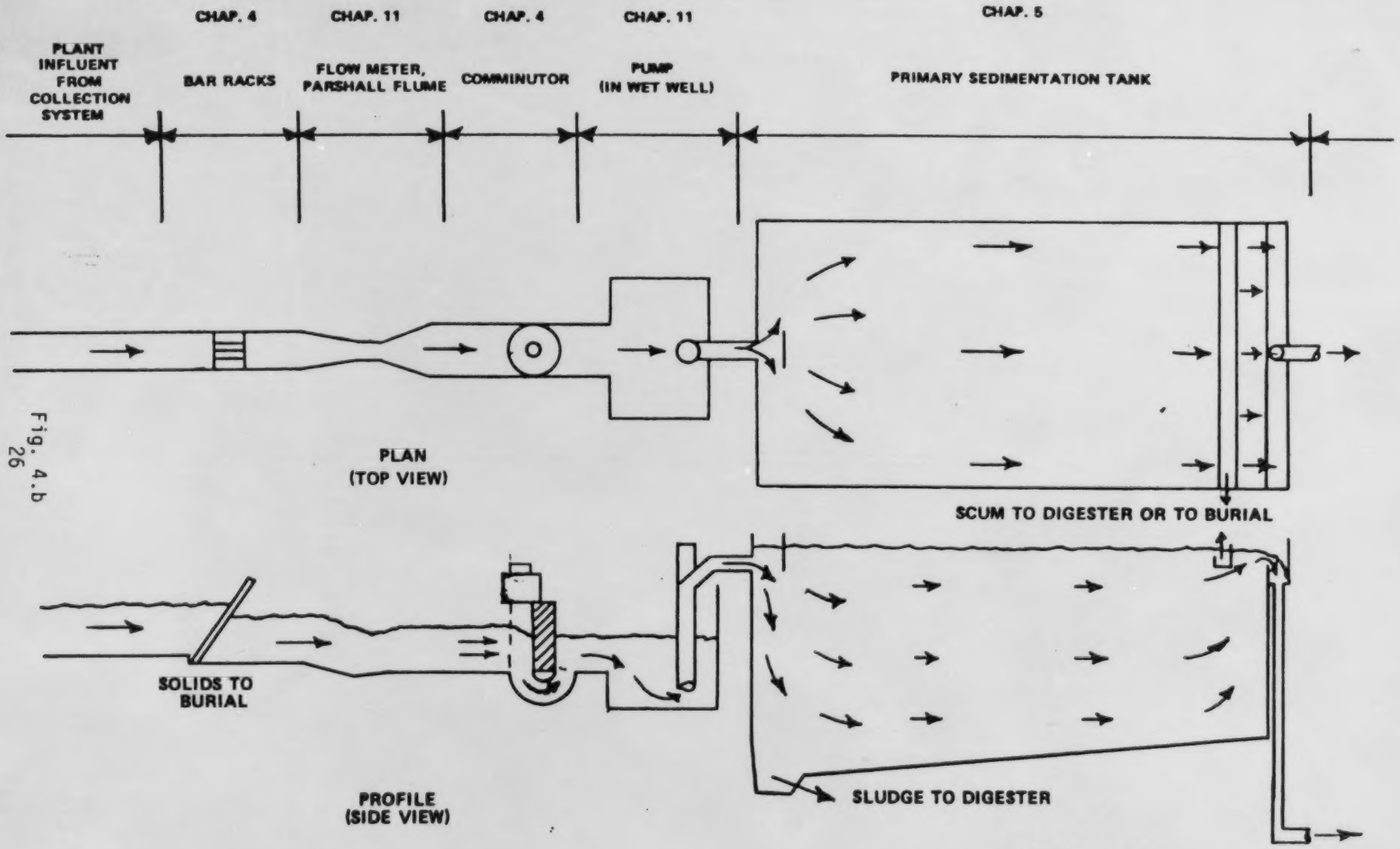


Fig. 4.b 26

NOTE: SOLIDS FLOW NOT SHOWN, SEE SECTION 3.7

50

Possible flow pattern through a trickling filter plant

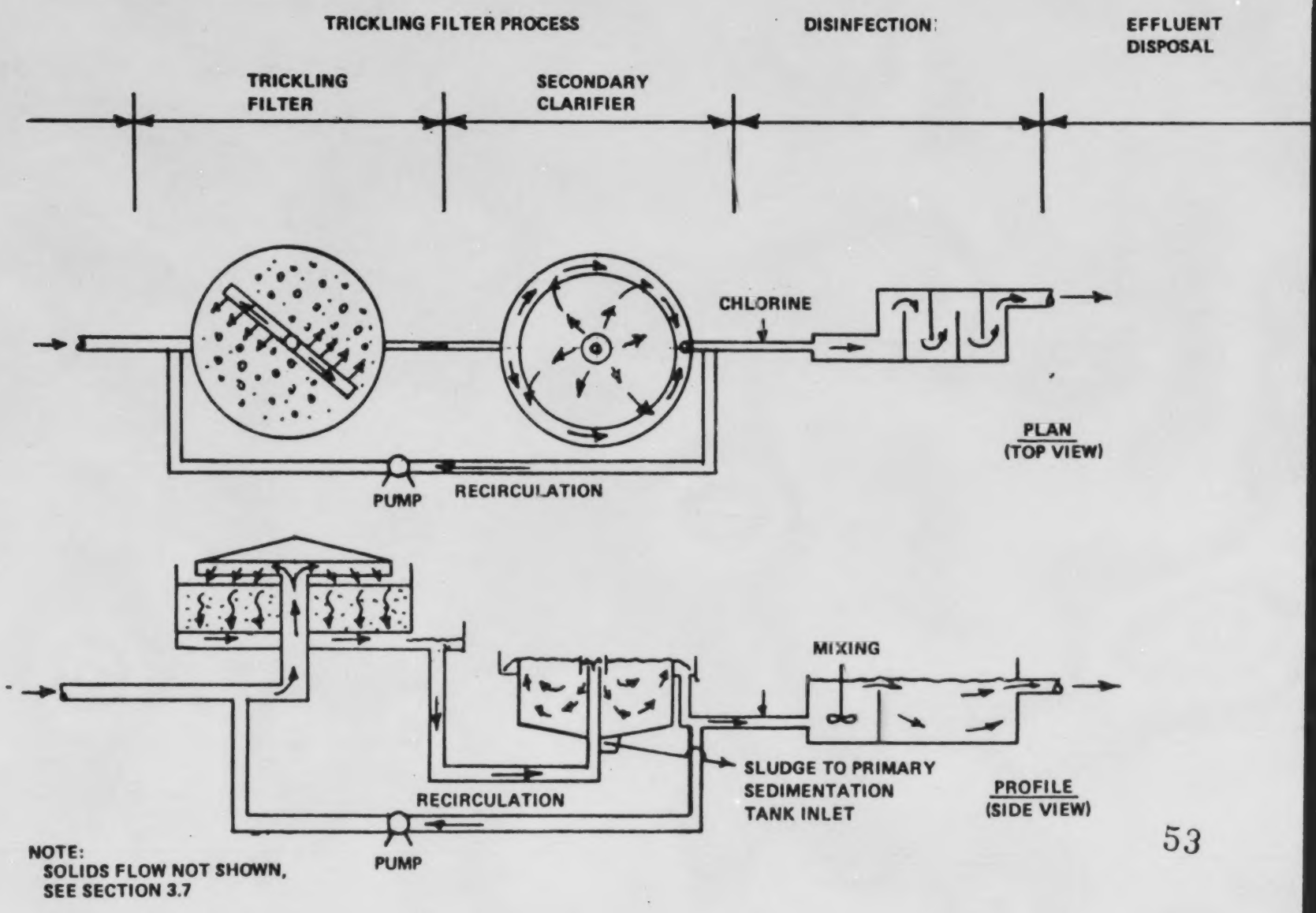


Fig. 4.b (Con'd)
27

(Con'd) Possible flow pattern through a trickling filter plant

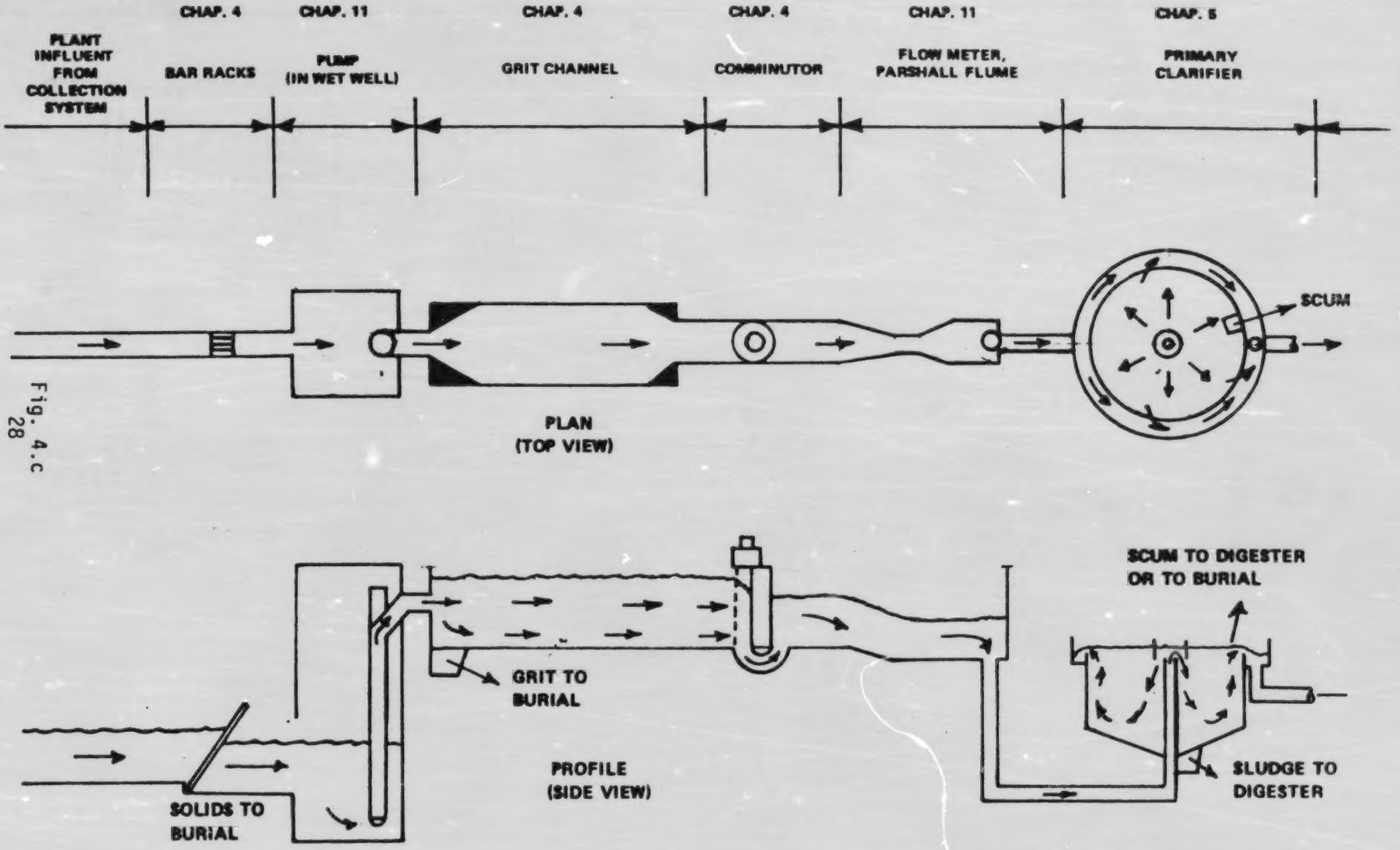
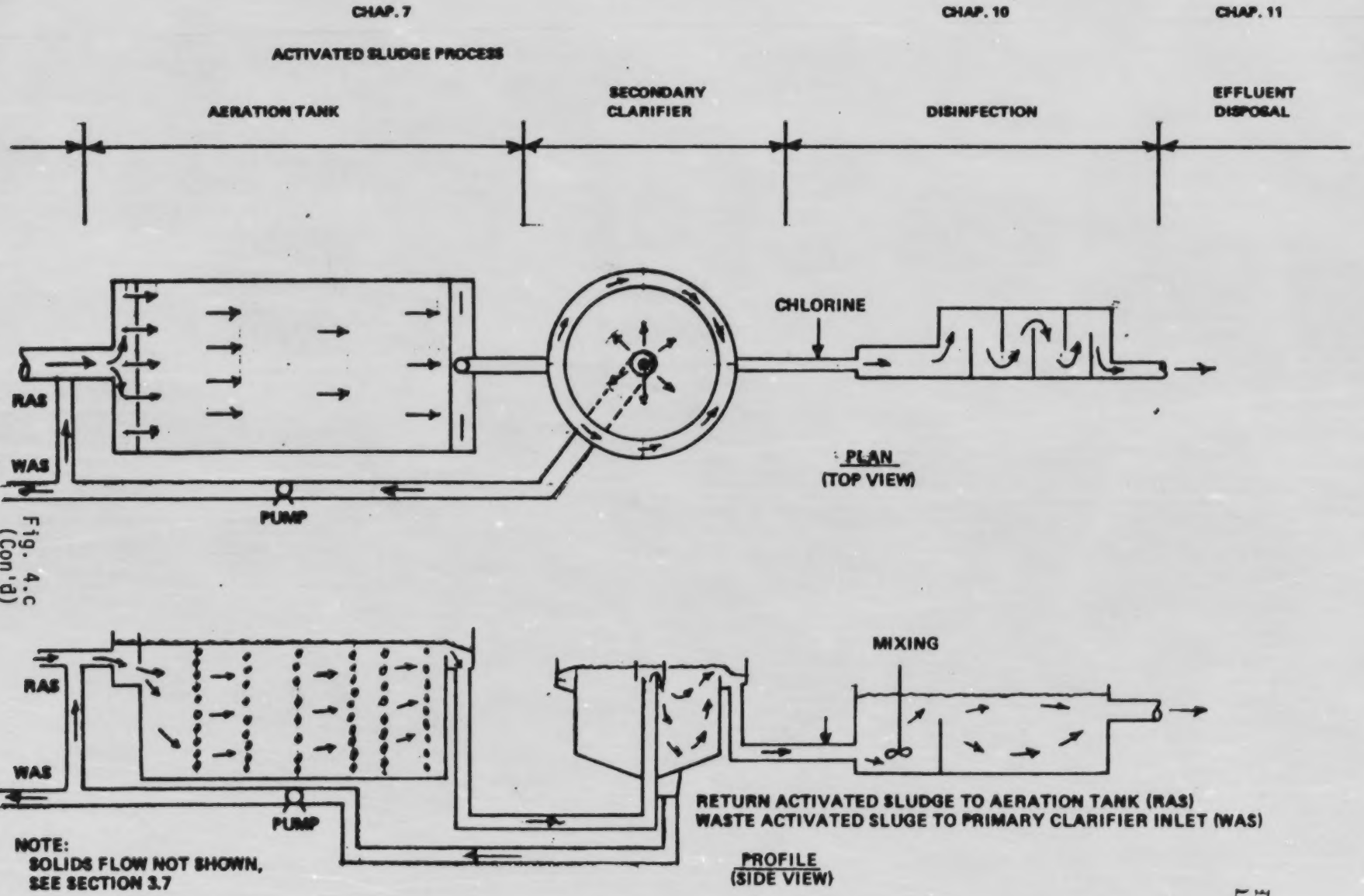


Fig. 4.c 28

NOTE: SOLIDS FLOW NOW SHOWN, SEE SECTION 3.7

Possible flow pattern through an activated sludge plant



29

Fig. 4.c (Con'd)

(Con'd) Possible flow patterns through an activated sludge plant

Lesson Outline	Lecture Notes
3.32 Shredding 1. Barminutor 2. Comminutor 3. Intended to shred or cut up material in wastewater to prevent damaging and/or plugging of pumps and pipes. 3.33 Grit Chambers or Grit Channels 1. Intended to remove heavy inorganic materials 2. Flow through velocity of 1 foot per second	

Week 3 Hour 2 Chapter: 3
Wastewater Facilities

Lesson Outline

Objectives:

1. Identify flow measuring devices and primary and secondary treatment processes.
2. Describe purpose and how flow measuring devices and primary and secondary treatment processes work.

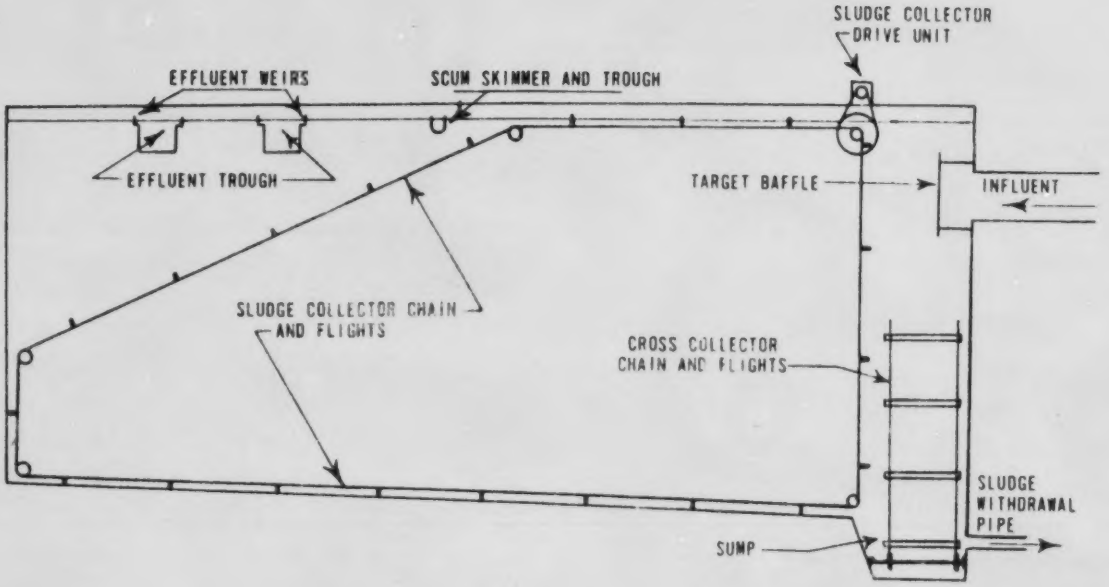
Lecture Outline

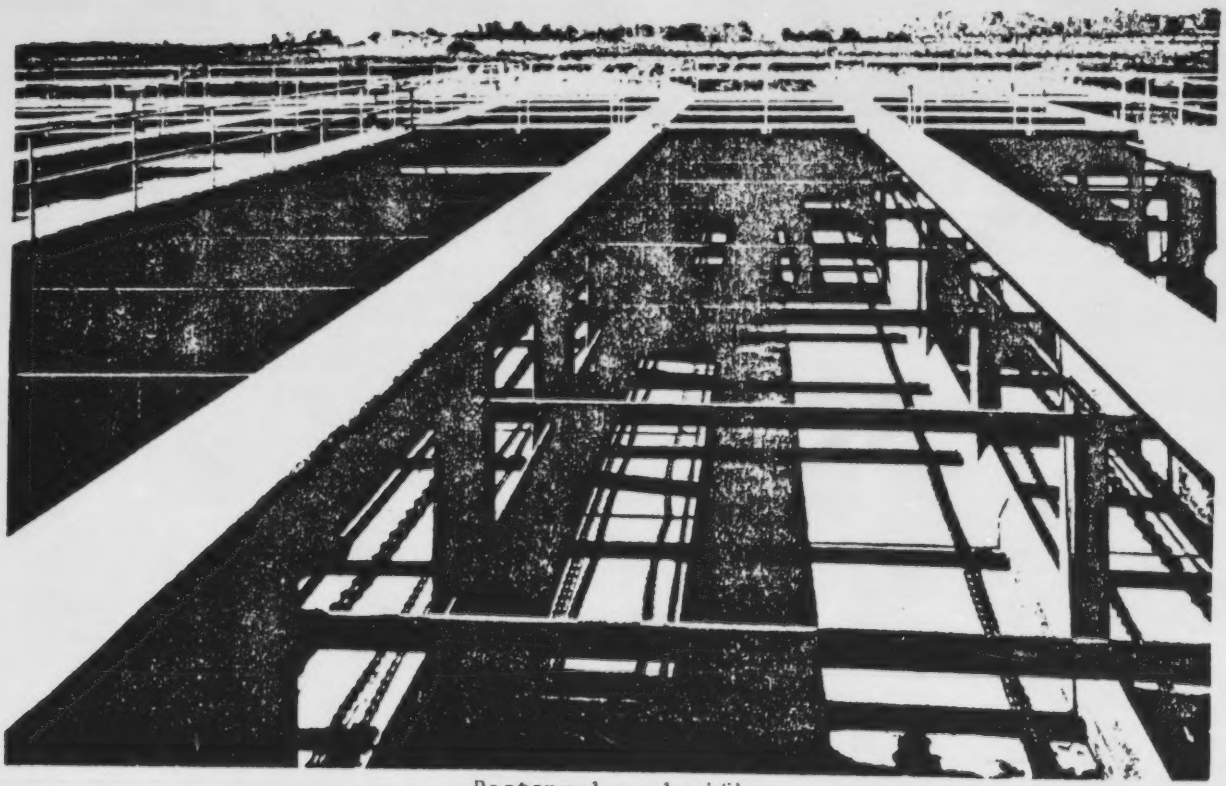
3.4 Flow Measuring Devices

1. Flow measuring devices are not for treating wastes; however, you must know the quantity of wastewater flow so adjustments can be made on pumping rates, chlorination rates, aeration rates, and other processes in the plant. Flow rates must be known also, for calculation of loadings on treatment processes and treatment efficiency.
2. Parshall flumes
3. Weirs

Lecture Notes

Lesson Outline	Lecture Notes
4. Advantages of Parshall flumes over weirs 5. Magnetic flow meters 6. Other devices used in local plants 3.5 Primary Treatment Refer to Fig.5, Rectangular clarifier and Fig. 6, Circular clarifier 1. Rectangular or circular sedimentation tanks or clarifiers. 2. Removal of suspended solids and biochemical oxygen demand (BOD) 3. Define and explain meaning of BOD 4. Removal of sludge 5. Define and explain sludge 6. Removal of scum 3.6 Secondary Treatment 3.60 Purpose Provide an environment for living organisms (such as bacteria) to eat the dissolved and non-settleable organic material remaining in the waste.	



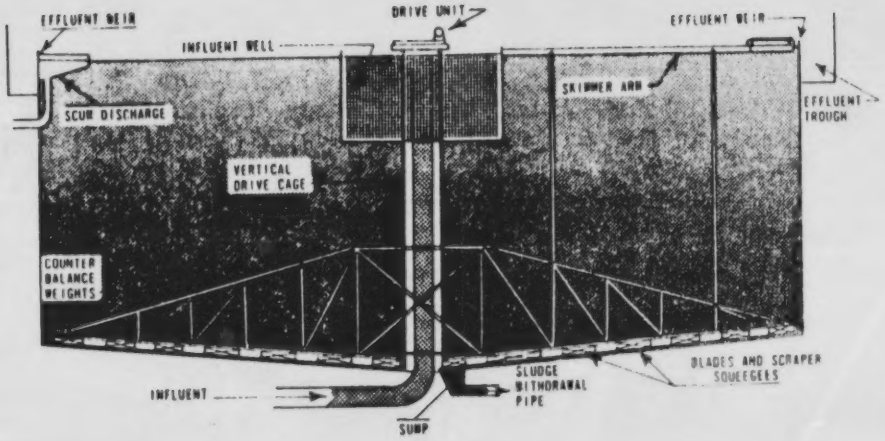


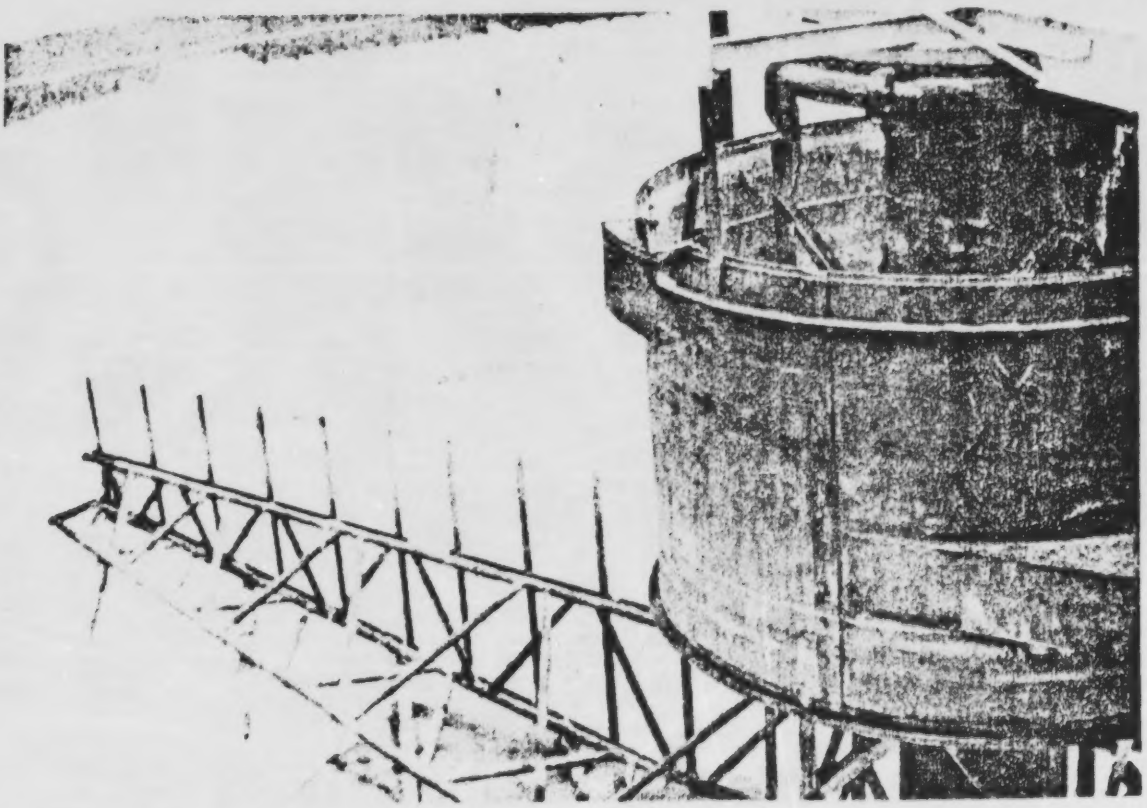
Rectangular clarifier

(Courtesy Jeffrey)

Fig. 5

61

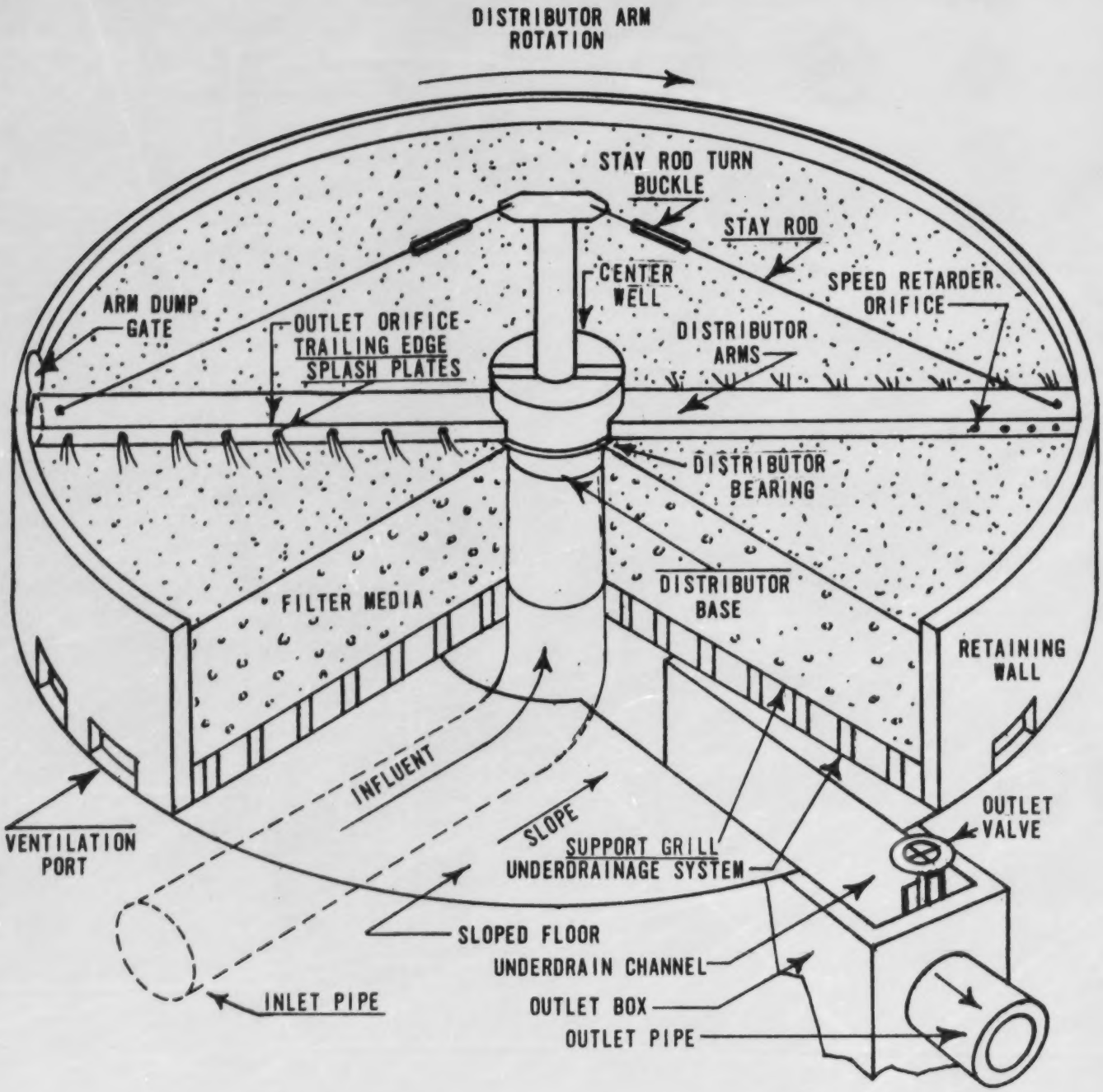




Circular clarifier

Fig. 6

Lesson Outline	Lecture Notes
3.61 Describe trickling filter process (See Fig. 7) a. Application of wastewater b. Trickle over rocks or media c. Collection or underdrain system 3.62 Describe activated sludge process a. Entrance of wastewater to aeration tank b. Return activated sludge (RAS) c. Aeration devices d. Mixing of wastewater with return activated sludge e. How organisms treat waste 3.63 Secondary clarifiers a. Describe clarifier (similar to primary clarifiers) b. Purpose: To separate solids and organisms from water being treated and to produce a clear effluent. c. Sludge removal	



Trickling filter

Fig. 7

Week 3	Hour 3	Chapter: 3 Wastewater Facilities

Lesson Outline

Objectives:

1. Identify solids handling and disposal processes, waste treatment ponds, and effluent disposal techniques.
2. Describe purpose of solids handling and disposal processes, waste treatment ponds, and effluent disposal techniques and how they work.

Lecture Outline

3.7 Solids Handling and Disposal

3.70 Purpose

Digestion, decomposition and dewatering of sludge solids to a condition where they can be disposed of ultimately by burning (incineration) or burial in an approved sanitary landfill.

3.71 Digestion and dewatering

1. Settled sludge removed from primary clarifier to digester.

Lecture Notes

Lesson Outline	Lecture Notes
2. Aerobic digesters. An extension of the activated sludge process where sludge is aerated in an aeration tank. 3. Anaerobic digesters. (Refer to Figures 8a, 8b, and 9) An environment suitable for anaerobic bacteria to treat or digest the sludge. Acid forming bacteria eat or break down the organic portion of the sludge to form organic acids and carbon dioxide gas. A second group of bacteria called "gas formers" break down the organic acids to simpler compounds, and form methane and carbon dioxide gas. 4. Digester mixing 5. Separation of digested sludge and liquid (supernatant).	

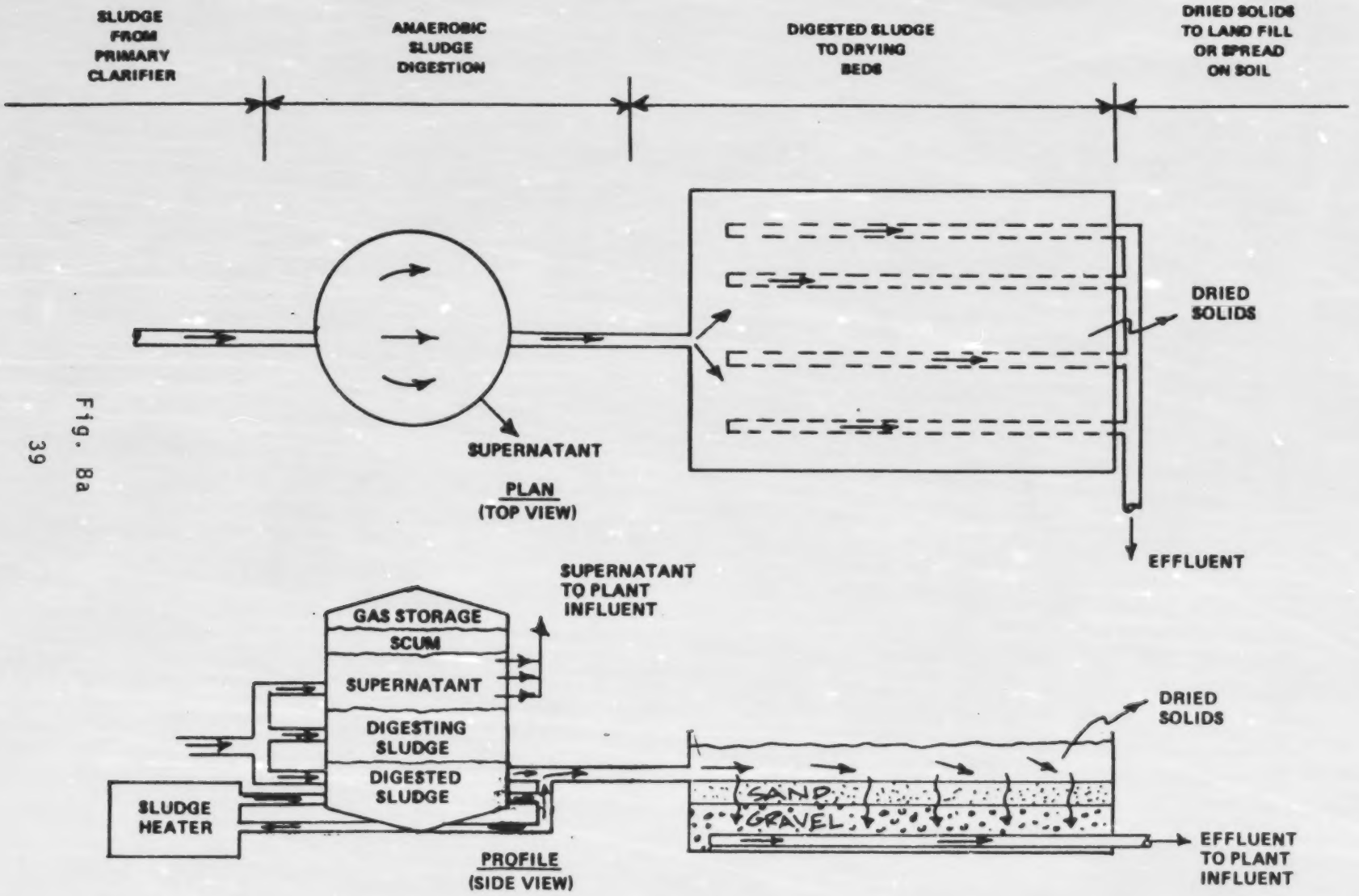


Fig. 8a

Possible sludge processing and solids disposal flow pattern
(sludge drying beds)

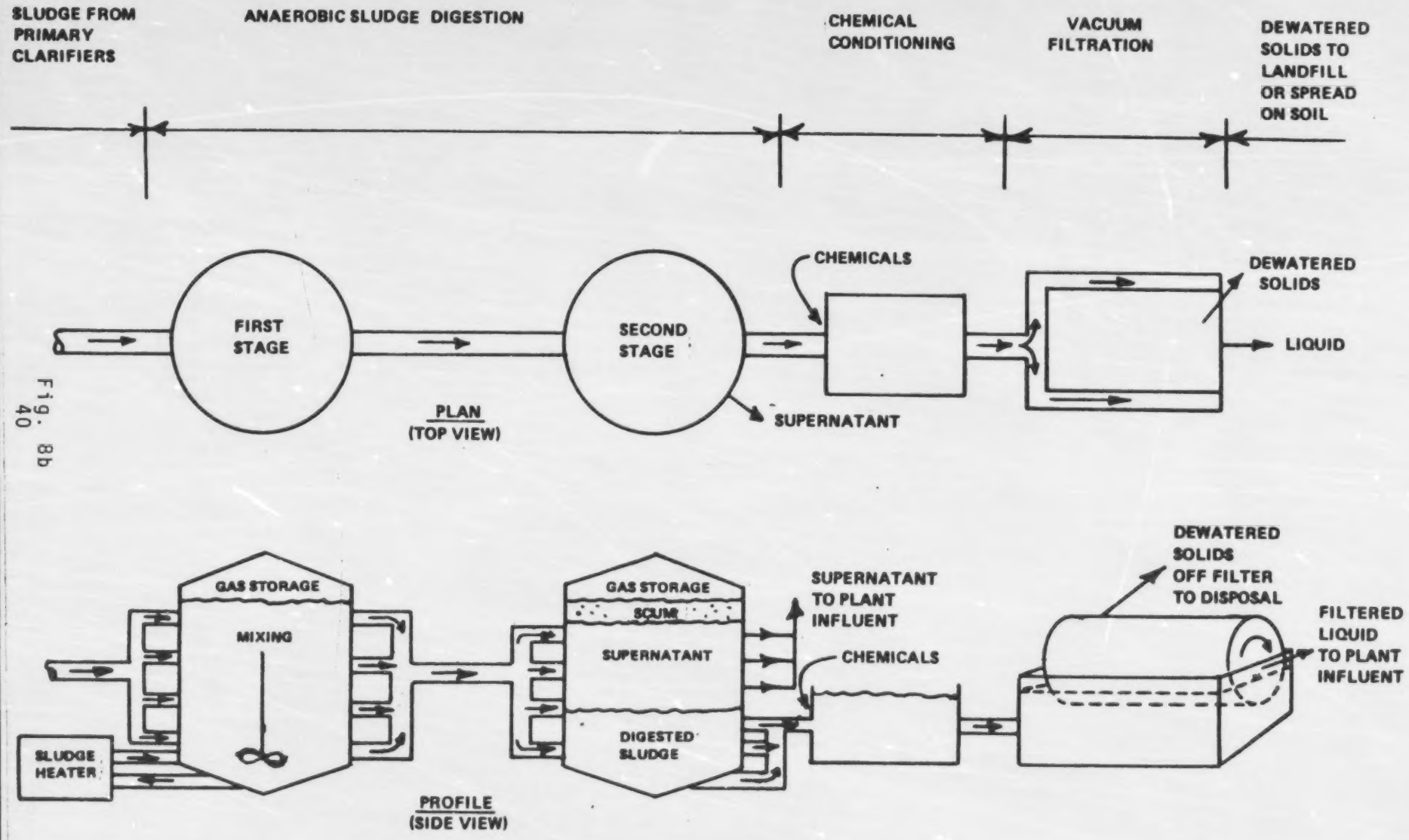


Fig. 40 8b

Possible sludge processing and solids disposal flow pattern (vacuum filtration)

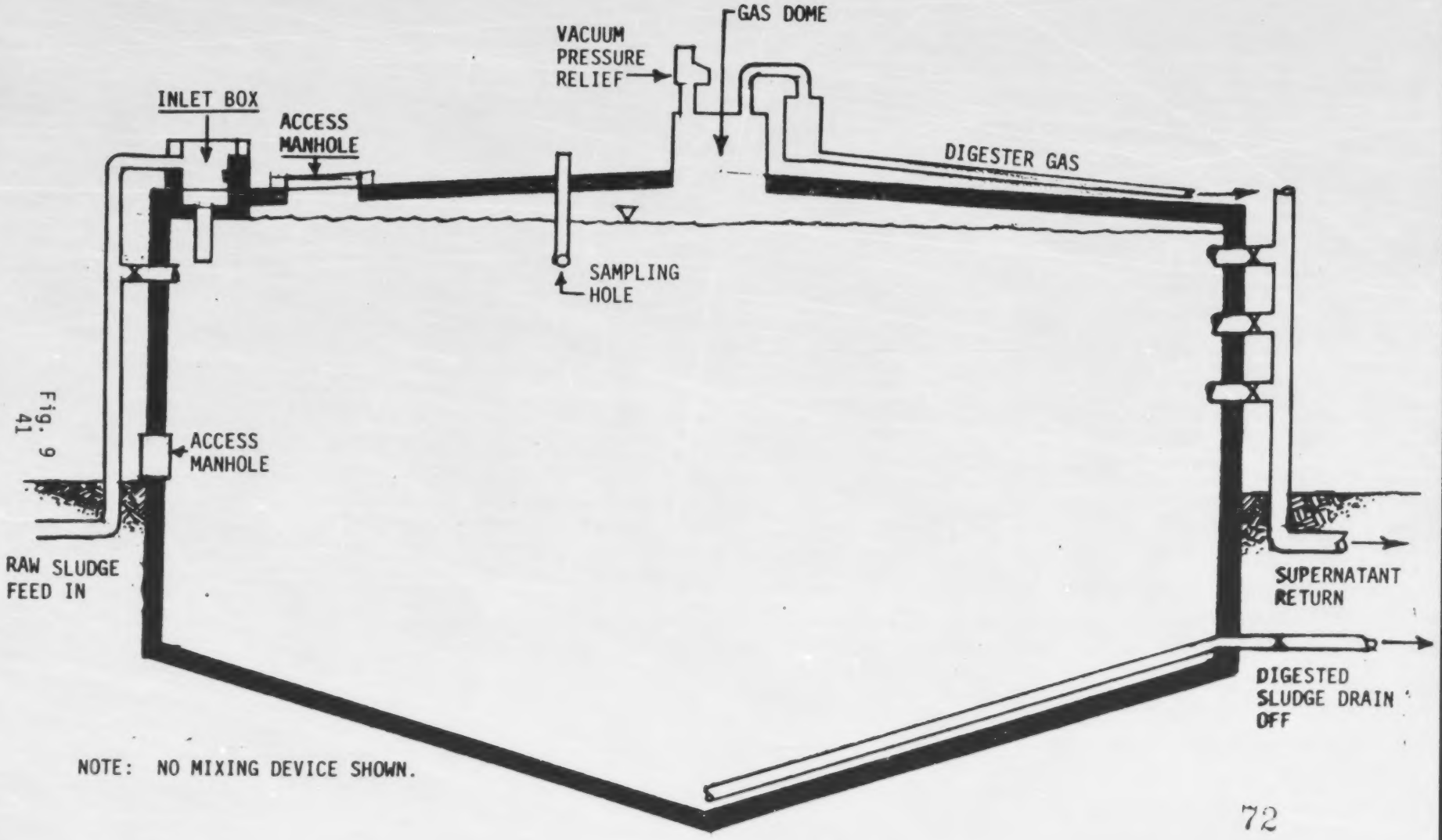


Fig. 41

71

72

Section of sludge digester

Week 3	Hour 3 (Con'd)	Chapter: 3 Wastewater Facilities

Lesson Outline	Lecture Notes
NOTE: In many anaerobic digesters the liquid will not separate from the digested sludge even after two days of no mixing. If this happens, there will be no supernatant. 6. Scum blanket 7. Digester gas a. Fuel value for heating sludge and other uses b. Explosive potential 8. Sludge dewatering Sand drying beds, lagoons, centrifuges, and vacuum filters. 9. Ultimate disposal Burning (incineration), burial in an approved sanitary landfill, possibility of use as a fertilizer or soil conditioner if hazards from viruses and toxic substances can be avoided.	

Week 3	Hour 3 (Con'd)	Chapter: 3 Wastewater Facilities

Lesson Outline	Lecture Notes
3.8 Waste Treatment Ponds 1. Describe ponds 2. Purpose of ponds 3. How ponds treat wastewater 3.9 Advanced Methods of Treating Wastewater 1. Purpose: To remove specific waste constituents from the effluent from secondary biological treatment processes. 2. Advance methods of waste treatment include coagulation - sedimentation (used in water treatment plants), microscreening, phosphorus removal, and nitrification (conversion of ammonium, NH_4^+, to nitrate, NO_3^-). 3.10 Disinfection 1. Purpose: Killing of pathogenic (disease causing) bacteria. 2. Disinfection commonly accomplished by the application of chlorine to the plant's effluent (chlorination). 3. Use of chlorine gas and hypochlorite solution.	

Week 3	Hour 3 (Con'd)	Chapter: 3 Wastewater Facilities

Lesson Outline	Lecture Notes
4. Chlorine contact basins 5. Dechlorination a. Purpose: To dechlorinate effluent so it won't be toxic to aquatic organisms. b. Method: Use of sulfur dioxide (SO_2) gas (Sulfonation) Sulfonators are similar to chlorinators. 6. Odor control by chlorination. 3.11 Effluent Disposal 1. Dilution 2. Land disposal 3. Recharging ground water 4. Wastewater reclamation a. Industrial reuse b. Parks and landscaping c. Future demands 3.12 Solids Disposal	

Week 3	3- Hour Lab (Optional)	Chapter: 3 Wastewater Facilities

Lesson Outline	Lecture Notes
Objective: Visit a water treatment plant or an advanced wastewater treatment plant to familiarize yourself with this type of treatment plant. Assignment: 1. Describe the purpose of each treatment process and how it works. 2. Prepare a list of tasks done by the operators. OR Objective: Tour a wastewater collection system to become familiar with the sources of wastewater. Assignment: 1. List the sources of wastewater and the characteristics of the wastewater from the major sources. 2. Prepare a list of sewer maintenance activities that could adversely influence wastewater characteristics and flows into a wastewater treatment plant.	

CHAPTER 4

RACKS, SCREENS, COMMINUTORS AND GRIT REMOVAL

Week 4	Hour 1	Chapter: 4 Racks, Screens, Comminutors and Grit Removal

Lesson Outline	Lecture Notes
Objectives: Refer to objectives listed at the beginning of Chapter 4, Racks, Screens Comminutors and Grit Removal. Assignment: Objective test and discussion and review questions at end of Chapter 4. Lecture Outline Glossary: Review new words 4.0 Caution 1. Think Safety 2. Follow safe procedures 3. Good personal hygiene must be observed at all times. Always wash your hands thoroughly before eating or smoking! 4. Beware of slow moving equipment 4.1 Pretreatment Refer to Fig. 10, Flow diagram of a typical plant 1. Material and wastes found in plant influent. 2. Purpose: To remove sand, eggshells, and similar materials (grit) that can plug pipes, cause excessive wear in pumps, and use up valuable	

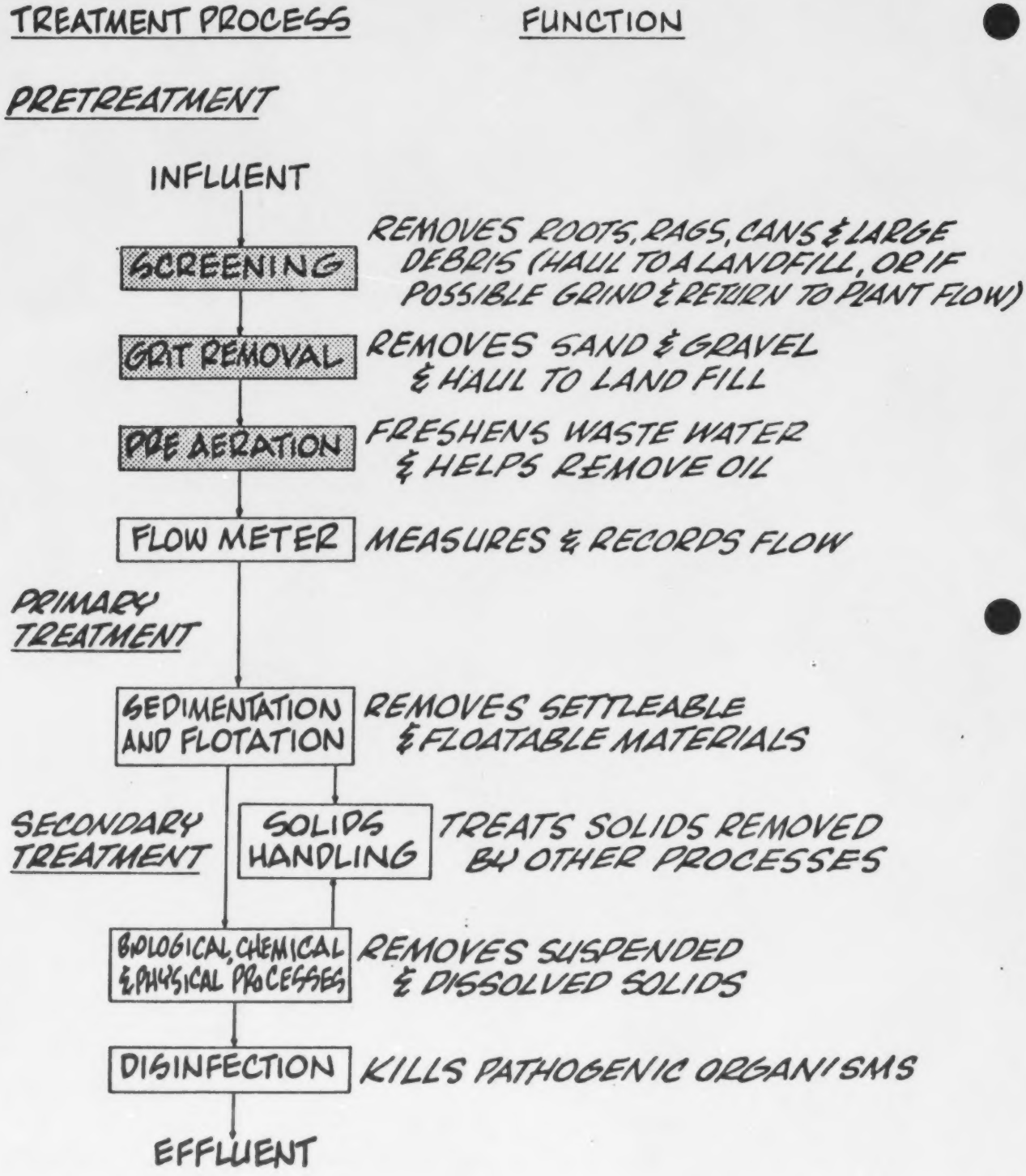

TREATMENT PROCESS
FUNCTION
PRETREATMENT
INFLUENT
SCREENING
REMOVES ROOTS, RAGS, CANS & LARGE DEBRIS (HAUL TO A LANDFILL, OR IF POSSIBLE GRIND & RETURN TO PLANT FLOW)
GRIT REMOVAL
REMOVES SAND & GRAVEL & HAUL TO LAND FILL
PRE AERATION
FRESHENS WASTE WATER & HELPS REMOVE OIL
FLOW METER
MEASURES & RECORDS FLOW
PRIMARY TREATMENT
SEDIMENTATION AND FLOTATION
REMOVES SETTLEABLE & FLOATABLE MATERIALS
SECONDARY TREATMENT
SOLIDS HANDLING
TREATS SOLIDS REMOVED BY OTHER PROCESSES
BIOLOGICAL, CHEMICAL & PHYSICAL PROCESSES
REMOVES SUSPENDED & DISSOLVED SOLIDS
DISINFECTION
KILLS PATHOGENIC ORGANISMS
EFFLUENT

Fig. 10
47

Week 4	Hour 1 (Con'd)	Chapter: 4 Racks, Screens, Comminutors and Grit Removal

Lesson Outline	Lecture Notes
space in sludge digesters. Also, grit is very difficult to remove from digesters. 3. Problems caused by plugged pipes, jammed collector mechanisms or malfunctioning pumps. 4. Screening 5. Grit Removal 6. Preaeration 4.2 Bar Screens and Racks 1. Describe bar screens and racks 2. Purpose: To remove heavy coarse materials 3. Mechanical cleaning method 4.20 Safety around bar screens and racks 1. Slipping and falling 2. Drowning 3. Disease 4. Back injuries and muscle strain 5. When working on mechanical equipment, tag controls,	

Lesson Outline	Lecture Notes
lock power off and take the key with you!	
4.21 Manually cleaned bar screens	
1. Purpose and components of manually cleaned bar screens (See Table 4.1, Second Edition).	
2. What happens if too much debris collects on bars and wastewater backs up in sewer?	
4.22 Mechanically cleaned screens	
1. Describe equipment	
2. Beware of slow moving equipment	
3. Trouble-shooting. Rake will not move.	
a. Rake mechanism jammed; or	
b. Equipment broken	
4.23 Operational Procedures	
1. Routine operation	
2. Abnormal operation resulting from storms or sewer cleaning operations by maintenance crews.	

Lesson Outline	Lecture Notes
3. Removal from operation or shut down 4.3 Disposal of Screenings 1. Reasons for disposal. 2. Methods of disposal (burial, incineration, and shredding or grinding). 3. Problems caused by use of shredders and grinders. 4. Calculation of volume or filling rate for screenings in a sanitary landfill operation. 5. Calculation of volume or capacity of disposal pit. 6. Calculation of days or time to fill disposal pit.	

Week 4	Hour 2	Chapter: 4 Racks, Screens, Comminutors and Grit Removal

Lesson Outline	Lecture Notes
Objectives: Refer to objectives listed at the beginning of Chapter 4, Racks, Screens Comminutors and Grit Removal. Lecture Outline 4.4 Comminution 4.40 Comminutors 1. Description of comminutor 2. Purpose and components of comminutors (Table 4.2, Second Edition) 3. Maintenance 4. Safety. Never attempt to unplug or unjam the cutter blades without FIRST by-passing the unit and then turning off the electrical power, locking out switches and placing tags on the switches indicating who did it and when. Keep the key in your pocket. 4.41 Barminutors 1. Describe barminutor	

Week 4	Hour 2 (Con'd)	Chapter: 4 Racks, Screens, Comminutors and Grit Removal

Lesson Outline	Lecture Notes
2. Purpose of barminutor components (Table 4.3, Second Edition) 3. Maintenance 4. Safety 4.42 Operational Procedures 1. Routine operation 2. Abnormal operation resulting from sudden high flows or heavy amounts of debris (from industrial dumps, sewer lines maintenance on storm flows) 3. Start up and shut down 4.5 Grit Removal 1. Grit (sand, eggshells, and cinders) is the heavier mineral matter in wastewater that will not decompose or "break down". 2. Grit causes excessive wear in pumps. 3. Grit, tar and grease can form a solid mass in pipes and digesters that will not move and cannot be removed by ordinary means.	

Lesson Outline	Lecture Notes
4. Grit should be removed as soon as possible after it reaches a treatment plant. 4.6 Grit Channels 1. Velocity, 0.7 to 1.4 ft/sec (0.2 to 0.4 m/sec) 2. Objective: To allow grit to settle to the bottom of the grit channel while keeping the lighter organic solids moving along to the next treatment unit. 3. Control of velocity in grit channel 4. Purpose of grit channels and components (Table 4.4, Second Edition) 5. Calculation of velocity in grit channel. Velocity, ft/sec = $\frac{\text{Distance, ft}}{\text{Time, sec}}$ OR Velocity, ft/sec = $\frac{\text{Flow, cu ft/sec}}{\text{Area, sq ft}}$ 6. Causes of dead spots and corrective action 7. Frequency of cleaning and methods of cleaning	

Week 4	Hour 2 (Con'd)	Chapter: 4 Racks, Screens, Comminutors and Grit Removal

Lesson Outline	Lecture Notes
8. Safety a. Take precautions against slipping and back strain b. Beware of dangerous gases and lack of oxygen when working in covered grit channels 9. Start up 10. Normal operation 11. Abnormal operation 12. Shut down 13. Maintenance Aerated Grit Chambers 1. Description 2. Purpose of aerated grit chamber and components 3. Start up 4. Normal operation 5. Abnormal operation 6. Shut down	

Week 4	Hour 3	Chapter: 4 Racks, Screens, Comminutors and Grit Removal

Lesson Outline	Lecture Notes
Objectives: Refer to objectives listed at the beginning of Chapter 4, Racks, Screens, Comminutors and Grit Removal. Lecture Outline 4.7 Cyclone Grit Separators 1. Describe cyclone grit separator 2. Purpose of cyclone grit separator and components (Table 4.6, Second Edition) 4.70 Safety 4.71 Start Up 4.72 Operation 1. Feed 2. Underflow discharge 3. Feed inlet pressure and overflow discharge 4.73 Shut down 4.74 Maintenance 4.8 Grit Washing 1. Purpose: To remove undersirable organic matter that settles with the grit. 2. Purpose of grit washer and components (Table 4.7, Second Edition)	

Week 4	Hour 3 (Con'd)	Chapter: 4 Racks, Screens, Comminutors and Grit Removal

Lesson Outline	Lecture Notes
3. Start up 4. Normal operation 5. Shut down 6. Maintenance 4.9 Quantities of Grit 1. For separate sanitary collection systems, average 1 to 4 cu.ft. of grit per million gallons of flow. 2. For combined wastewater collection systems, 4 to 15 cu. ft. of grit per million gallons. 4.10 Disposal of Grit Final disposal of grit is by burial with at least 6 inches of soil placed over the grit to keep out rats and flies. 4.11 Preaeration 1. Purpose: To help grit removal, freshen wastewater (remove gases and add oxygen), promote flotation of grease, and aid coagulation. 2. Describe process and equipment	

Week 4	Hour 3 (Con'd)	Chapter: 4 Racks, Screens, Comminutors and Grit Removal

Lesson Outline	Lecture Notes
4.12 Operational Strategy 1. Review normal operation 2. Decide how to respond to hydraulic and solids overloads 3. Prepare a plan for when sticks, rags and debris foul, plug or break equipment 4. Determine how downstream processes will have to be adjusted if pre-treatment processes must be by-passed. 4.13 Design Review Purpose: To allow operators the opportunity to suggest how treatment plants can be made easier to operate and maintain before they are constructed. 4.130 Racks and Screens 4.131 Grit Removal 4.132 Wet Wells	

Week 4	3-Hour Lab (Optional)	Chapter: 4 Racks, Screens, Comminutors and Grit Removal

Lesson Outline

Objectives: Visit a wastewater treatment plant and observe or help (if possible) the operator operate and maintain the following pretreatment equipment and processes:

1. Bar screens and racks
2. Comminutors and/or barminutors
3. Grit channels
4. Grit separators
5. Grit washers
6. Preaeration

Lecture Notes

Week 5	Hour 1	Chapters: 1 through 4

Lesson Outline

Objective: Review for Exam I.

1. Cover important material in Chapters 1 through 4.
2. Emphasize purpose of processes, equipment and components.
3. Discuss start up, normal and abnormal operation, and shut down of processes and equipment.
4. Outline maintenance procedures.
5. Review safety hazards and safe procedures.
6. Identify important items that should be considered when reviewing plans and specifications.
7. Outline trouble-shooting procedures.

Lecture Notes

Week 5 Hour 2 Chapters: 1 through 4

Lesson Outline	Lecture Notes
Objective: Exam I.	

Week 5 Hour 3 Chapters: 1 through 4

Lesson Outline	Lecture Notes
Objectives: 1. Review results of Exam I and correct all mistakes or errors. 2. Identify areas for future review and students who need additional help. NOTE: 1. If Exam I is not graded, continue on to Week 6, Hour 1, and review exam when available. 2. Some instructors may wish to schedule exams less frequently or more frequently and should feel free to do so.	

Week 5 3 - Hour Lab Chapter:
(Optional)

Lesson Outline	Lecture Notes
Suggest instructor select activity most suited to needs of students. 1. Perform maintenance or repair of a pump. OR 2. Draw diagrams of different types of plants.	

CHAPTER 5

SEDIMENTATION AND FLOTATION

Week 6	Hour 1	Chapter: 5 Sedimentation and Flotation

Lesson Outline	Lecture Notes
Objectives: Refer to objectives listed at beginning of Chapter 5, Sedimentation and Flotation. Assignment: Discussion and review questions at the end of Lessons 1, 2, and 3 and objective test at end of Chapter 5. Lecture Outline Glossary: Review new words 5.0 Purpose of Sedimentation and Flotation. Refer to diagrams of a typical plant, Figures 11, 12, 13 and 14. NOTE: Primary treatment plants (Fig. 12) are no longer built today. Most primary plants are being or have been converted to secondary treatment plants by the addition of the trickling filter or activated sludge process. 1. Sedimentation tanks or clarifiers provide an opportunity for material in wastewater to either settle to the bottom or float to the surface for removal from the water being treated. Sedimentation and flotation occur when wastewater	

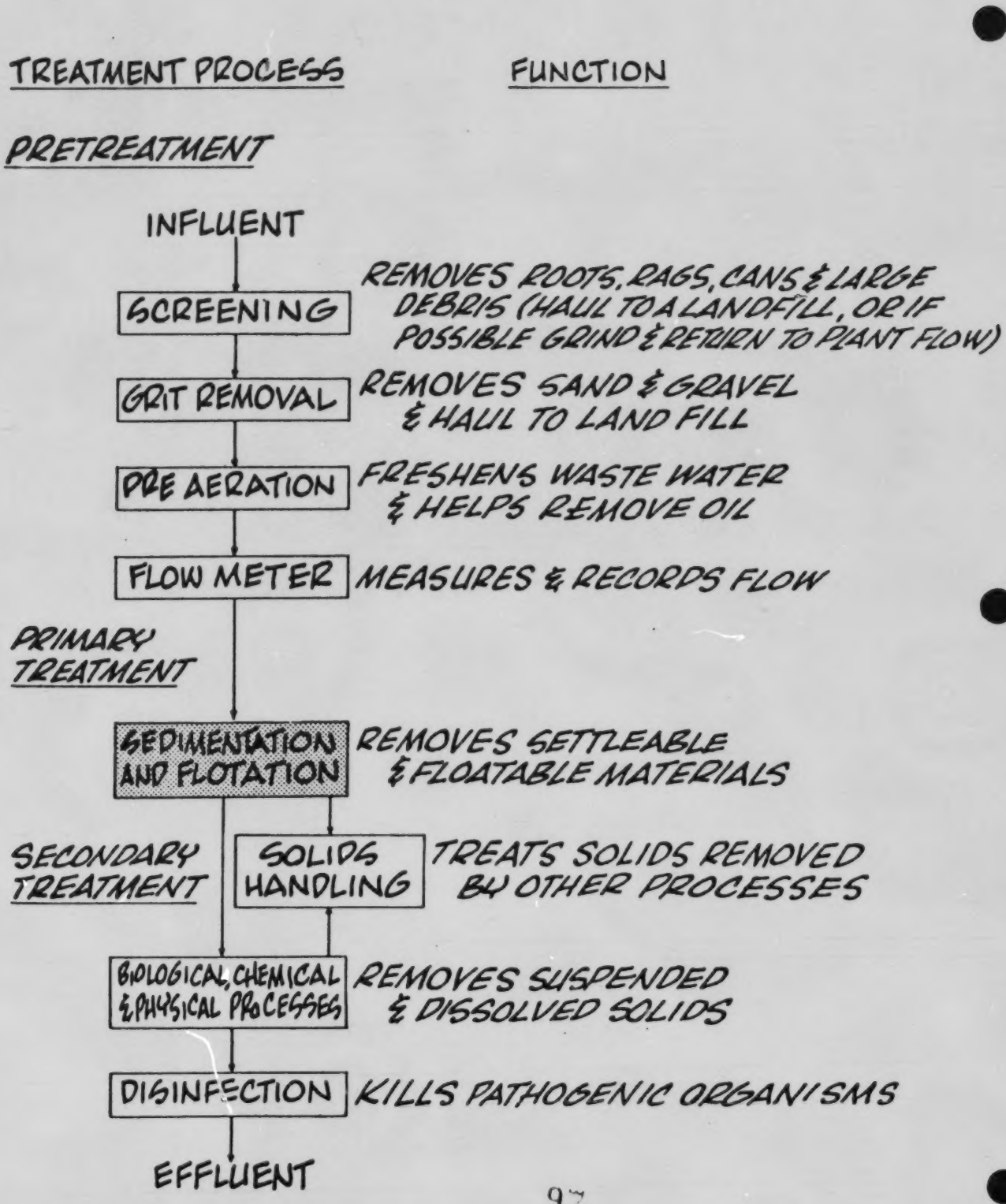

TREATMENT PROCESS
FUNCTION
PRETREATMENT
INFLUENT
SCREENING
REMOVES ROOTS, RAGS, CANS & LARGE DEBRIS (HAUL TO A LANDFILL, OR IF POSSIBLE GRIND & RETURN TO PLANT FLOW)
GRIT REMOVAL
REMOVES SAND & GRAVEL & HAUL TO LAND FILL
PRE AERATION
FRESHENS WASTE WATER & HELPS REMOVE OIL
FLOW METER
MEASURES & RECORDS FLOW
PRIMARY TREATMENT
SEDIMENTATION AND FLOTATION
REMOVES SETTLEABLE & FLOATABLE MATERIALS
SECONDARY TREATMENT
SOLIDS HANDLING
TREATS SOLIDS REMOVED BY OTHER PROCESSES
BIOLOGICAL, CHEMICAL & PHYSICAL PROCESSES
REMOVES SUSPENDED & DISSOLVED SOLIDS
DISINFECTION
KILLS PATHOGENIC ORGANISMS
EFFLUENT

Fig. 11

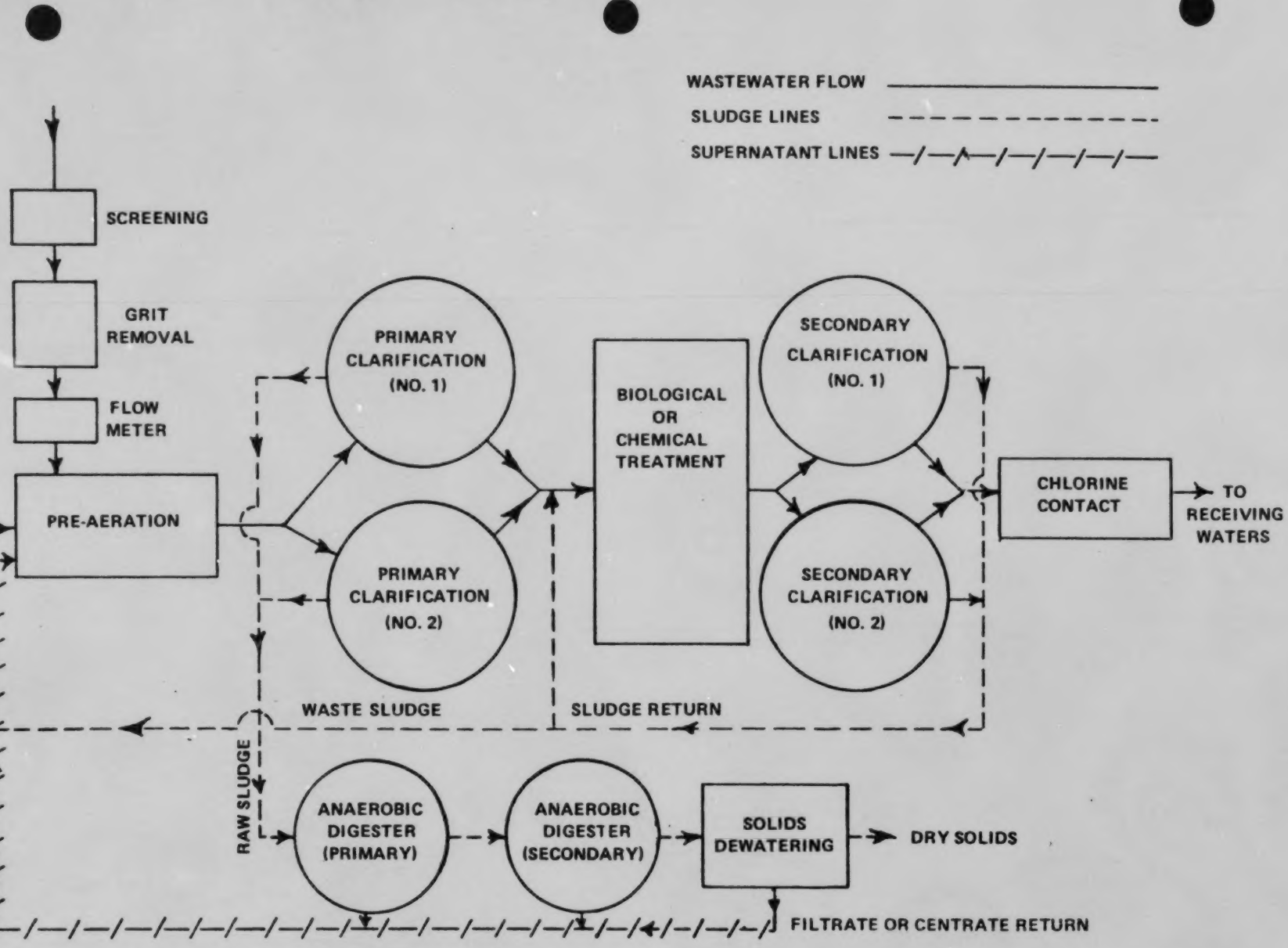


Fig. 12
65

Plan diagram of typical clarifiers in a wastewater treatment plant

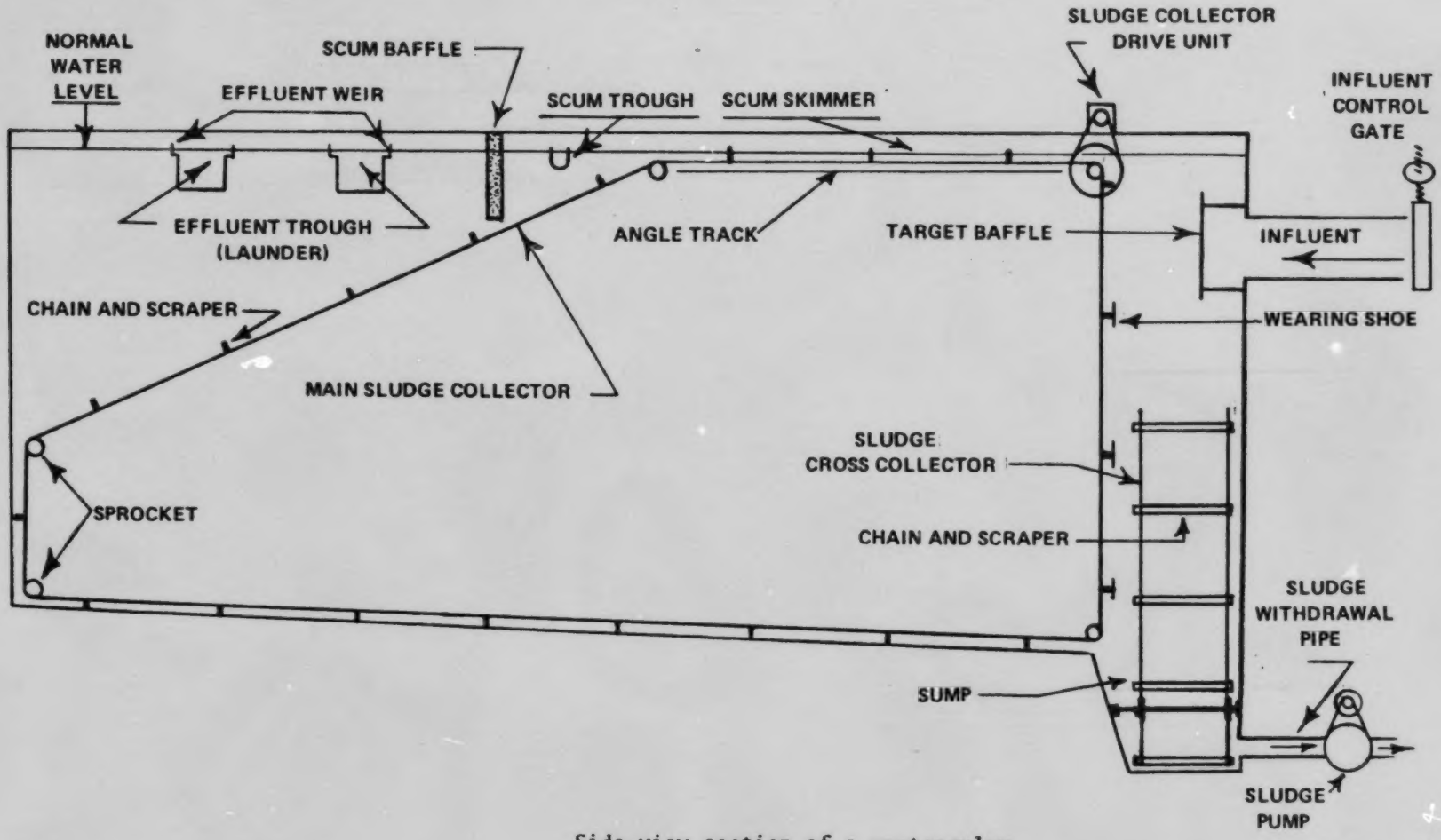


Fig. 13
66

Side-view section of a rectangular sedimentation basin

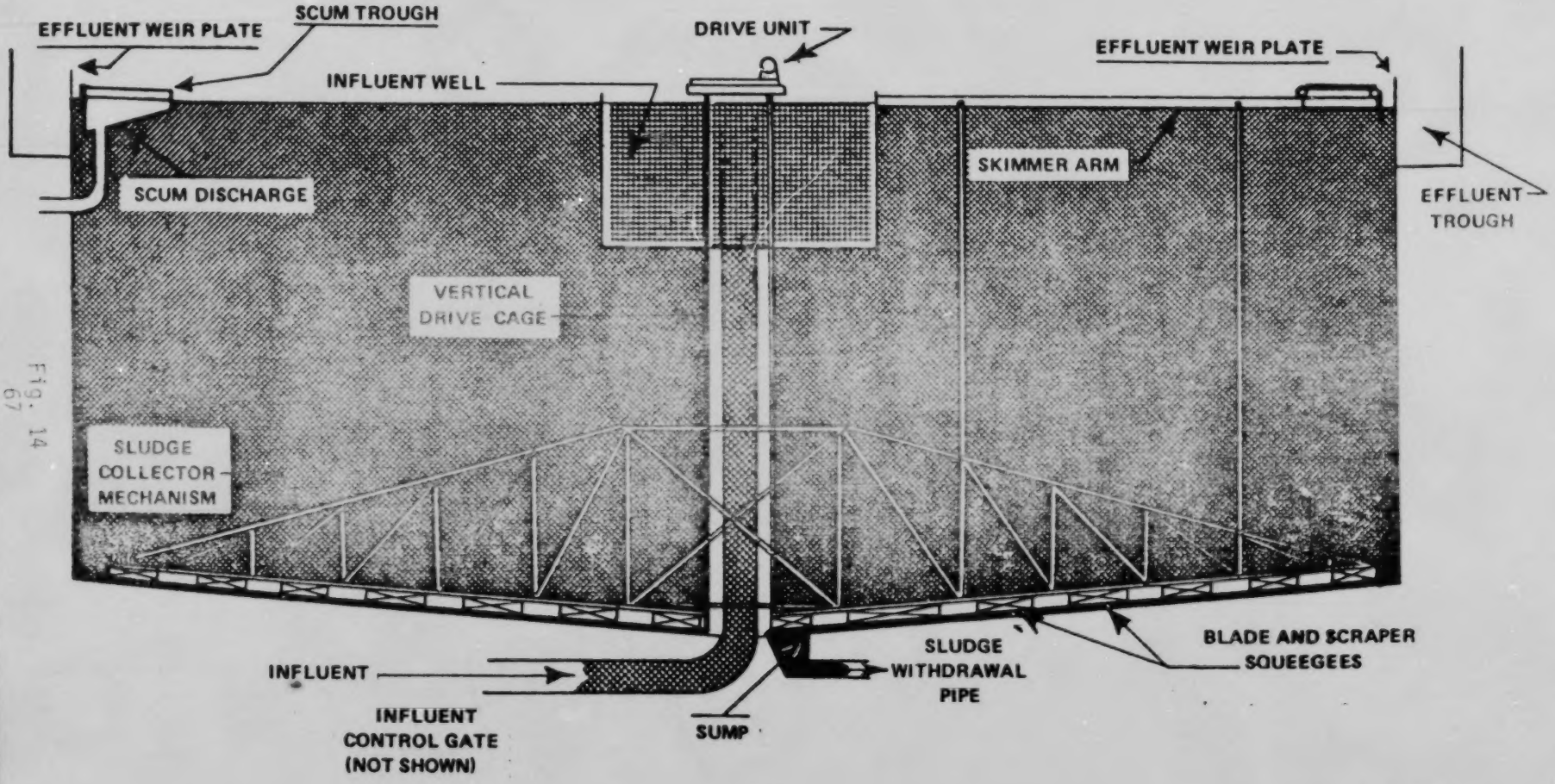


Fig. 14
67

Side-view section of a circular clarifier with blades and scraper squeegees

Lesson Outline	Lecture Notes
velocities are very slow. 2. Differences between primary clarifiers and secondary clarifiers. 3. Purpose and components in a rectangular sedimentation basin (Table 5.1, Second Edition, and Figures). 4. Purpose and components in a circular clarifier (Table 5.2, Second Edition and Figures). 5.1 Operation and Maintenance 5.10 Start-up Procedure 1. Circular clarifiers 2. Rectangular clarifiers 3. Safety precautions 5.11 Daily Operation and Maintenance 5.12 Shut-down Procedure (2nd Ed.) 5.13 Operational Strategy (2nd Ed.) 1. Purpose: Remove settleable and floatable solids by sedimentation and flotation. 2. Poor effluent may be the result of operator errors or equipment failures.	

Week 6	Hour 1 (Con'd)	Chapter: 5 Sedimentation and Floatation

Lesson Outline	Lecture Notes
3. Removal of settled solids 4. Skimming of floatables 5.14 Abnormal Conditions (2nd Ed.) 1. Toxic wastes from industrial dumps 2. Storm flows and hydraulic overloads. 3. Septicity from collection system problems. 5.15 Trouble-shooting (2nd Ed.) 1. Sludge collector failure 2. Sludge pump failure 3. Toxic waste discharge 5.2 Sampling and Laboratory Analysis 5.20 Need for Sampling and Analysis 1. Measure efficiency of clarifiers 2. Make appropriate process adjustments 5.21 Sampling Collect a representative sample 5.22 Calculations of clarifier efficiency	

Lesson Outline	Lecture Notes
1. Efficiency, $\% = \frac{(In - Out)}{In} \times 100\%$	
2. Work a typical problem	
5.23 Typical Clarifier Efficiencies	
5.24 Response to Poor Clarifier Performance	
1. Solids on surface	
2. Loss of solids over effluent weirs	
3. Poor efficiencies	
4. Pumping thin sludge	
5. Mechanical problems	
5.3 Sludge and Scum Pumping	
1. Septic conditions	
2. Sludge gasification	
3. Determination of sludge thickness during pumping	
5.4 General Maintenance	
1. Record keeping	
2. Lubrication	
3. Inspection	
4. Scheduling	

Week 6	Hour 1 (Con'd)	Chapter: 5 Sedimentation and Flotation

Lesson Outline	Lecture Notes
5.5 Safety 1. Gases 2. Falls 3. Drowning 4. Strains and overexertion 5. Electrical shock	

Week 6	Hour 2	Chapter: 5 Sedimentation and Flotation

Lesson Outline

Objectives: Refer to objectives listed Chapter 5, Sedimentation and Flotation

Lecture Outline

5.6 Principles of Operation

5.60 Types of Units

1. Primary clarifiers
2. Secondary clarifiers
3. Combined sedimentation-digestion units
4. Flotation units
5. Imhoff tanks

5.61 Primary Clarifiers

1. Purpose: Remove as much settleable and floatable material as possible.
2. Factors influencing design
3. Settling of particles
4. Temperature

   In general, as water temperature increases, settling rate of particles increases (less viscosity).
5. Short circuits
6. Detention time

Lecture Notes

Week 6	Hour 2 (Con'd)	Chapter: 5 Sedimentation and Flotation

Lesson Outline

Detention time, hours =

$$\frac{\text{Tank Vol, cu. ft. x 7.5 gal/cu. ft. x 24 hr/day}}{\text{Flow, gal/day}}$$

7. Calculate detention time
8. Evaluation and discussion of calculated detention time.
9. Weir overflow rate

Weir overflow rate, gpd/ft = $\frac{\text{Flow Rate, gpd}}{\text{Length of weir, ft.}}$

10. Calculate weir overflow rate
11. Evaluation and discussion of calculated weir overflow rate
12. Surface settling rate or surface loading rate

Surface loading rate, gpd/sq.ft. = $\frac{\text{Flow Rate, gpd}}{\text{Area, sq. ft.}}$

13. Calculate surface loading rate
14. Evaluation and discussion of calculated surface loading rate.
15. Solids loading

Solids loading, lbs/day/sq. ft. = $\frac{\text{Solids Applied, lbs/day}}{\text{Surface Area, sq. ft.}}$

Lecture Notes

Week 6	Hour 2 (Con'd) Chapter: 5 Sedimentation and Flotation
Lesson Outline	**Lecture Notes**
16. Calculate solids loading 17. Evaluation and discussion of calculated solids loading.	

Week 6	Hour 3	Chapter: 5 Sedimentation and Flotation

Lesson Outline

Objectives: Refer to objectives listed in Chapter 5, Sedimentation and Flotation

Lecture Outline

5.62 Secondary Clarifiers

Purpose: To remove settleable solids and any remaining floatables from the effluent of biological treatment processes (trickling filters and activated sludge)

5.620 Trickling filter clarifiers

1. Detention Time - 2.0 to 3.0 hours
2. Surface loading - 800 to 1200 gpd/sq. ft.
3. Weir Overflow - 5,000 to 15,000 gpd/lineal ft
4. Sludge characteristics

5.621 Activated sludge clarifiers

1. Detention Time - 2.0 to 3.0 hours
2. Surface Loading - 300 to 1200 gpd/sq. ft.
3. Weir Overflow - 5,000 to 15,000 gpd/lineal ft.

Lecture Notes

Week 6	Hour 3 (Con'd)	Chapter: 5 Sedimentation and Flotation

Lesson Outline	Lecture Notes
4. Solids Loading - 1.0 to 2.5 lbs/day/ sq. ft. 5. Sludge removal mechanisms 6. Sludge characteristics 7. Return sludge rates (10 to 50% of plant inflow) 8. Wasting activated sludge rates 9. Gravity or flotation sludge thickeners 10. Instrumentation for monitoring conditions in clarifier and operation of clarifier 11. Laboratory testing 5.7 Review of Plans and Specifications (2nd Ed.) 5.70 Operation 5.71 Maintenance 5.72 Safety 5.8 Flotation Processes 1. Vacuum Flotation 2. Pressure Flotation 3. Details on these processes are in the Second Edtion, Volume III.	

Week 6	Hour 3 (Con'd)	Chapter: 5 Sedimentation and Flotation

Lesson Outline	Lecture Notes
5.9 Combined Sedimentation - Digestion Unit NOTE: This material is optional. If these typesof units are in your local area they should be discussed. 5.90 Purpose of unit 5.91 How the unit works Purpose and components of sedimentation - digestion unit (Refer to Table 5.3, 2nd Ed. and Figure 15) 5.92 Sampling and analysis 1. Inflow 2. Clarifier 3. Digestion 4. Effluent 5.93 Operation 1. Start-up procedures 2. Normal operation 3. Abnormal operation 4. Shut-down procedures 5.94 Maintenance 5.95 Safety 5.10 Imhoff Tanks 5.11 Septic Tanks	

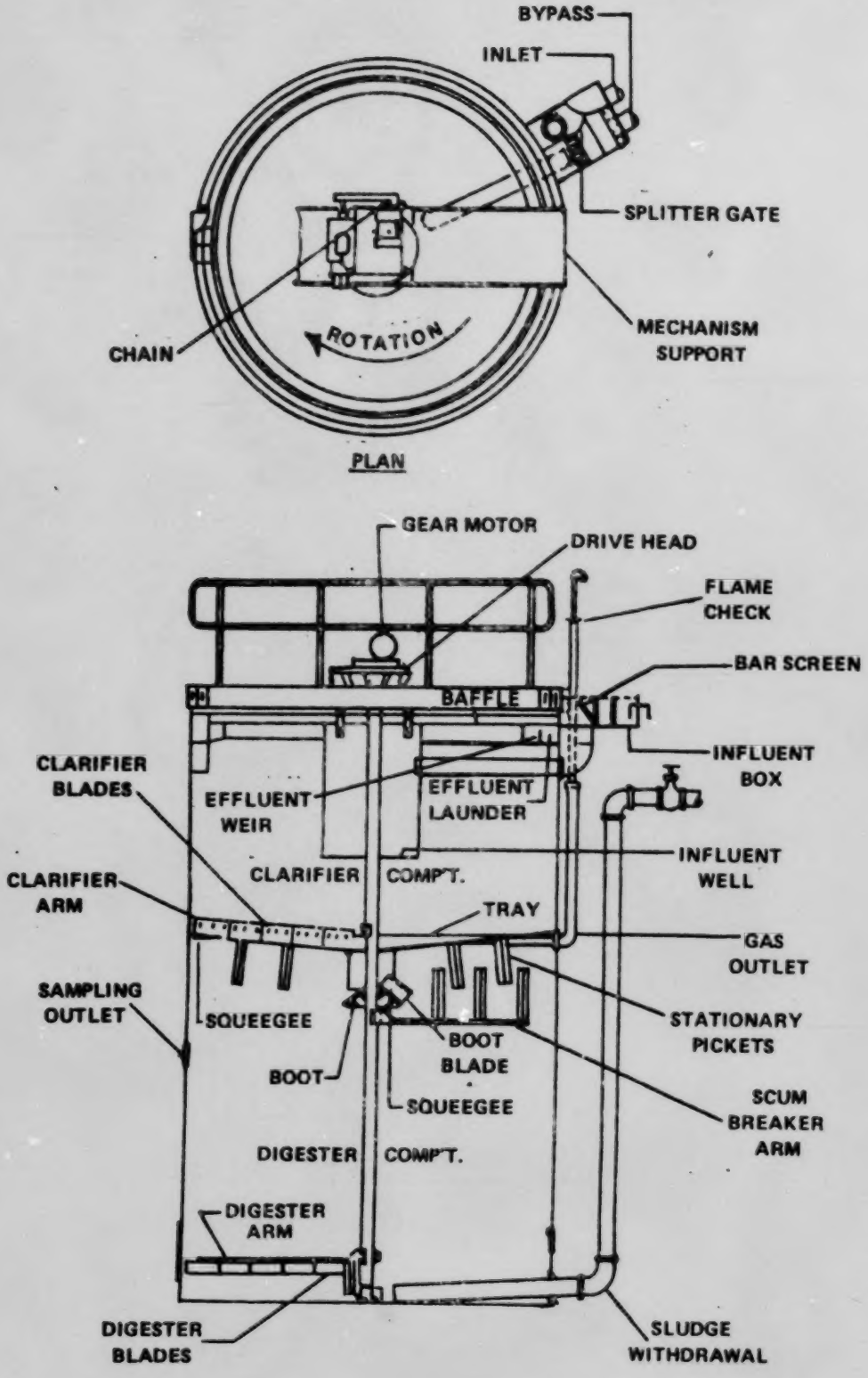


Fig. 15 - Combined sedimentation-digestion unit
(Permission of Dorr-Oliver Incorporated)

Week 6	3 -Hour Lab (Optional)	Chapter: 5 Sedimentation and Flotation

Lesson Outline	Lecture Notes
Objectives: Visit a wastewater treatment plant and observe or help (if possible) the operator operate and maintain a primary circular clarifier and/or a rectangular sedimentation tank.	

CHAPTER 6

TRICKLING FILTERS

Week 7	Hour 1	Chapter: 6 Trickling Filters

Lesson Outline	Lecture Notes
Objectives: Refer to objectives listed at the beginning of Chapter 6, Trickling Filters. Assignment: Discussion and review questions at the end of Lessons 1, 2, and 3 and the objective test at the end of Chapter 6. Lecture Outline Glossary: Review new words 6.0 How a Trickling Filter Works 6.00 Description of a trickling filter. Refer to Figures 16, 17 and 18 1. Describe how filter works 2. Purpose of trickling filter components (Refer to Table 6.1, 2nd Ed.) 6.01 Principles of Treatment Process 1. The media (and retaining structure) 2. The underdrain system 3. The distribution system 6.02 Principles of Operation 1. The maintenance of a good	

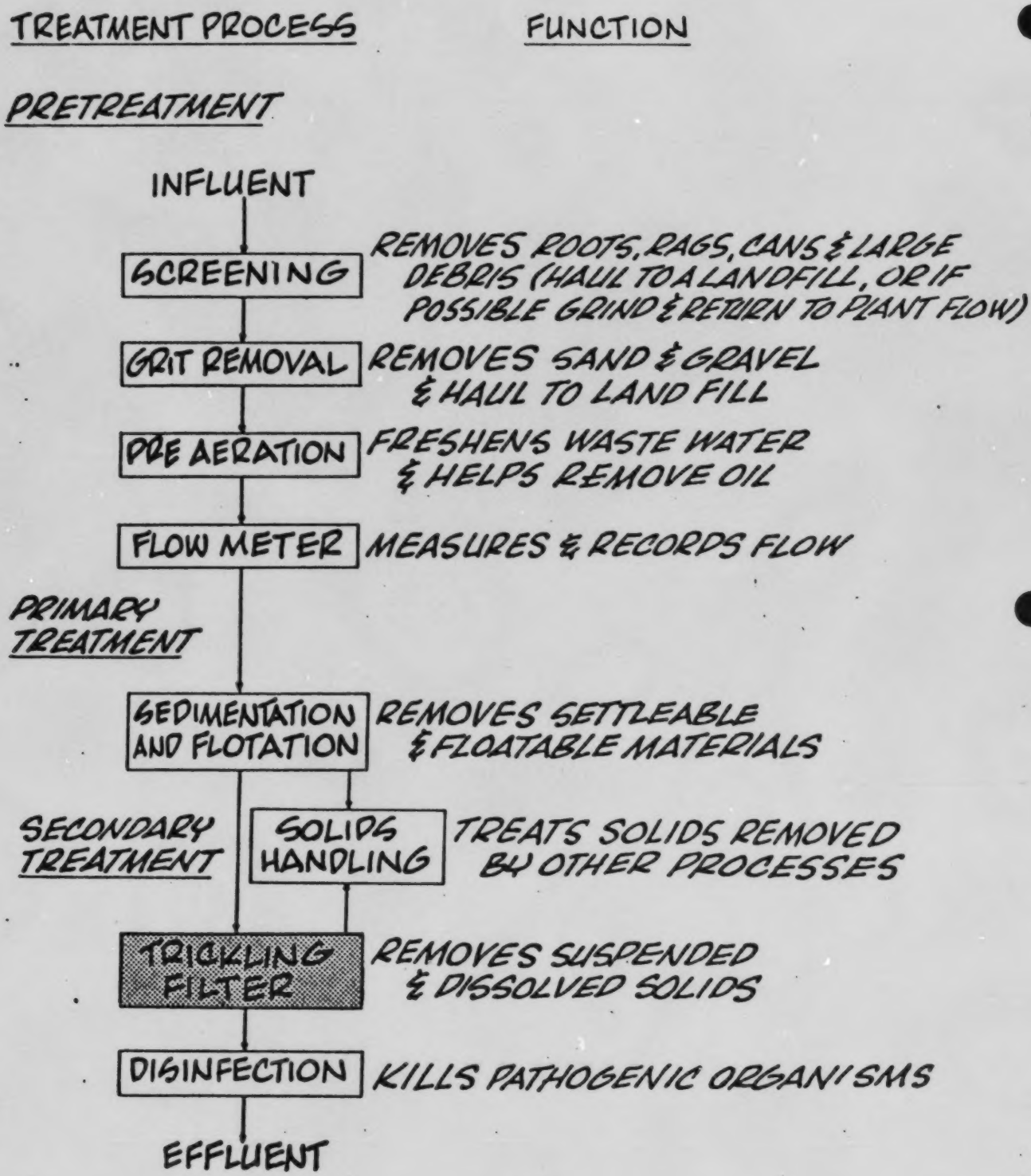

TREATMENT PROCESS
FUNCTION
PRETREATMENT
INFLUENT
SCREENING
REMOVES ROOTS, RAGS, CANS & LARGE DEBRIS (HAUL TO A LANDFILL, OR IF POSSIBLE GRIND & RETURN TO PLANT FLOW)
GRIT REMOVAL
REMOVES SAND & GRAVEL & HAUL TO LAND FILL
PRE AERATION
FRESHENS WASTE WATER & HELPS REMOVE OIL
FLOW METER
MEASURES & RECORDS FLOW
PRIMARY TREATMENT
SEDIMENTATION AND FLOTATION
REMOVES SETTLEABLE & FLOATABLE MATERIALS
SECONDARY TREATMENT
SOLIDS HANDLING
TREATS SOLIDS REMOVED BY OTHER PROCESSES
TRICKLING FILTER
REMOVES SUSPENDED & DISSOLVED SOLIDS
DISINFECTION
KILLS PATHOGENIC ORGANISMS
EFFLUENT

Fig. 16

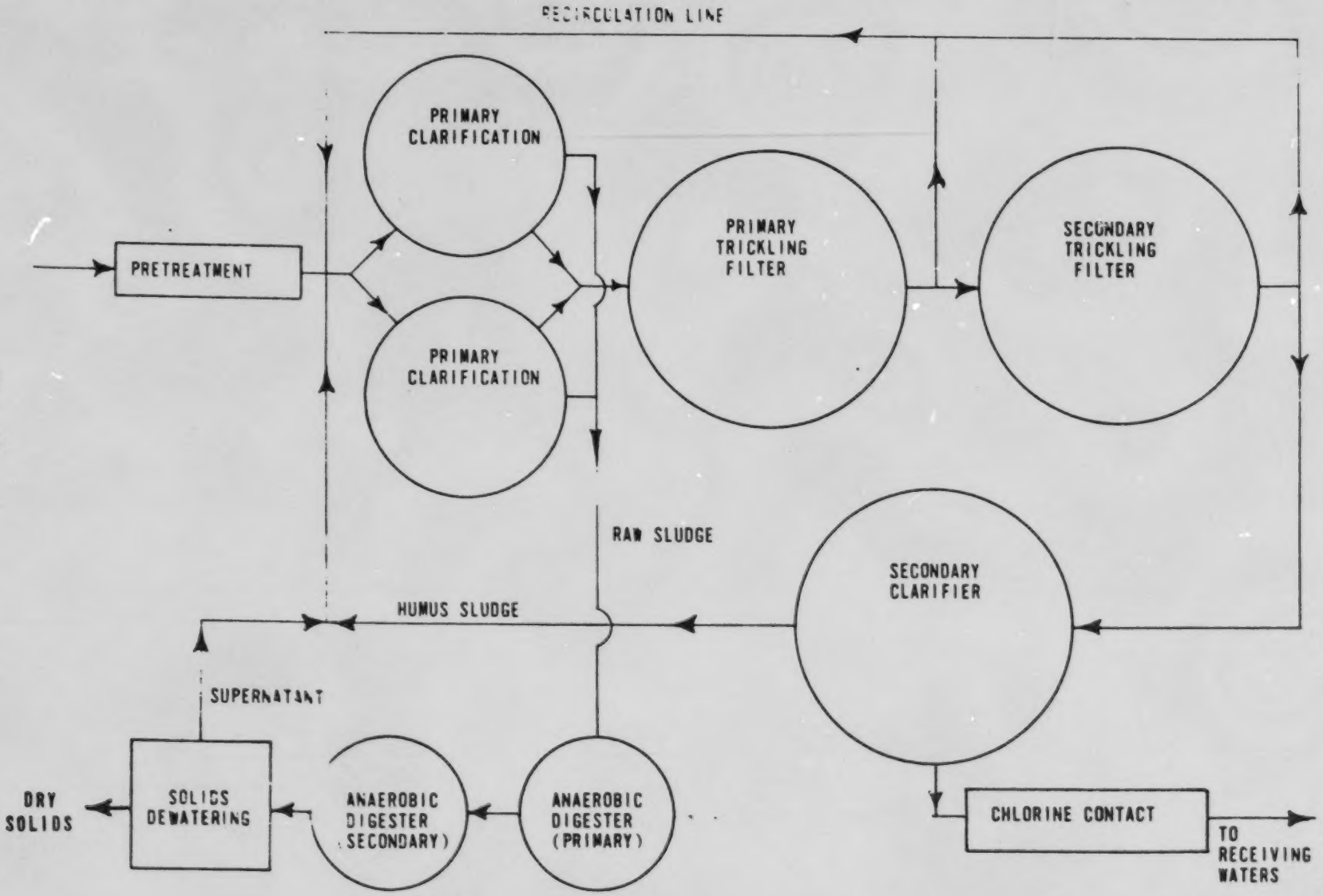


Fig. 17
82

Plan of typical trickling filter plant

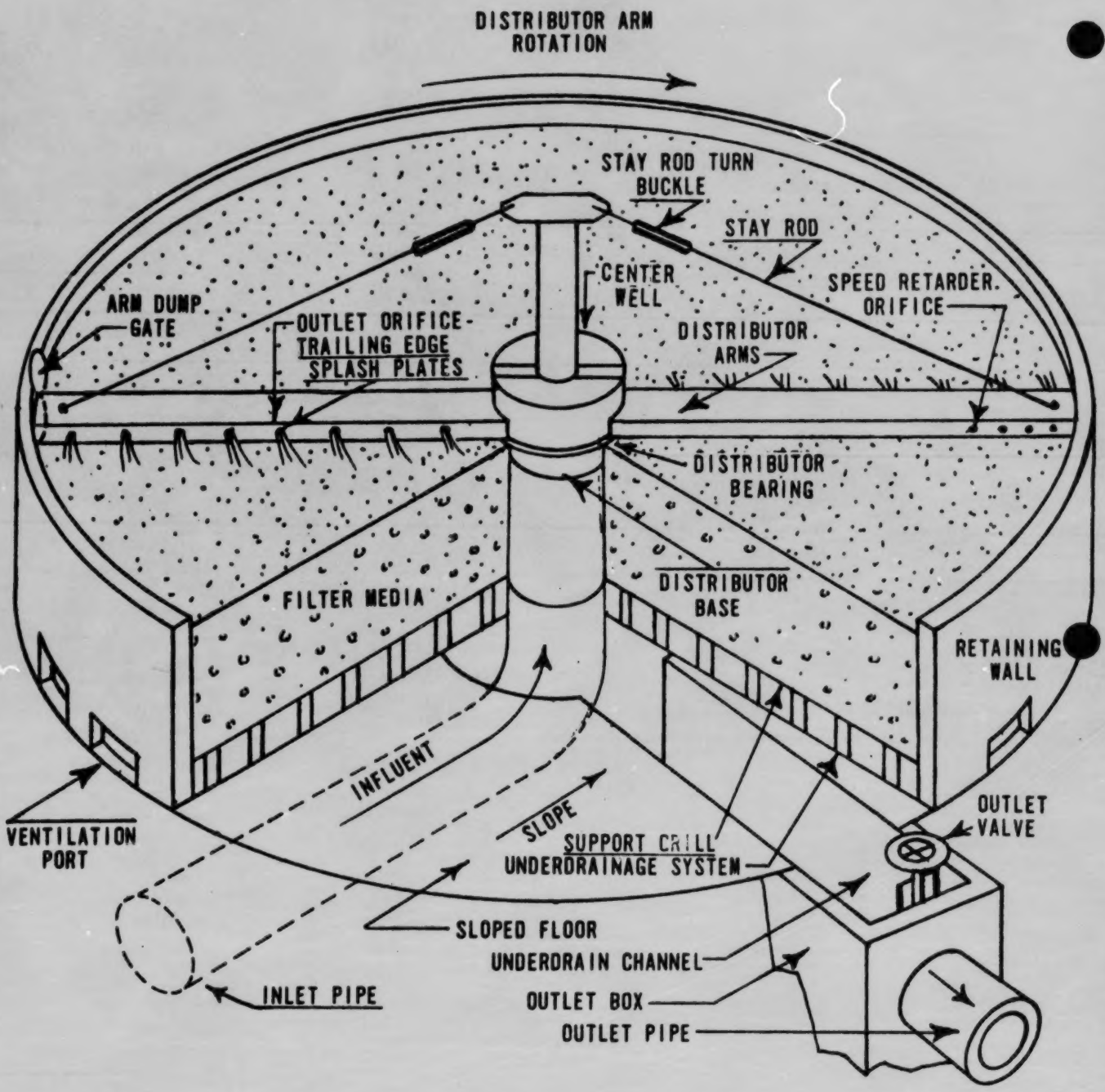
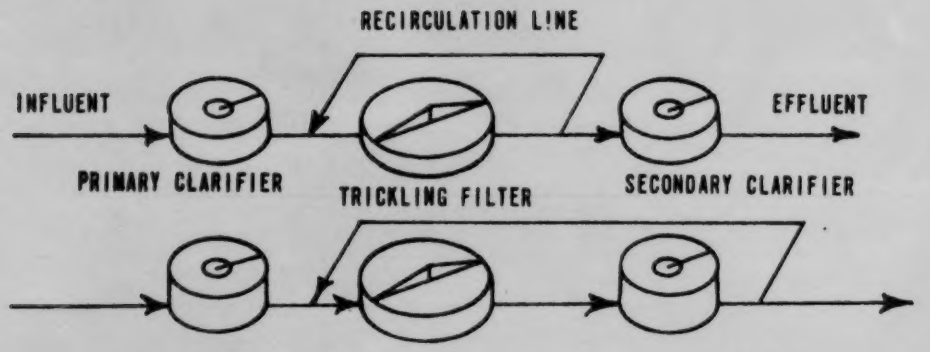


Fig. 18, Trickling filter

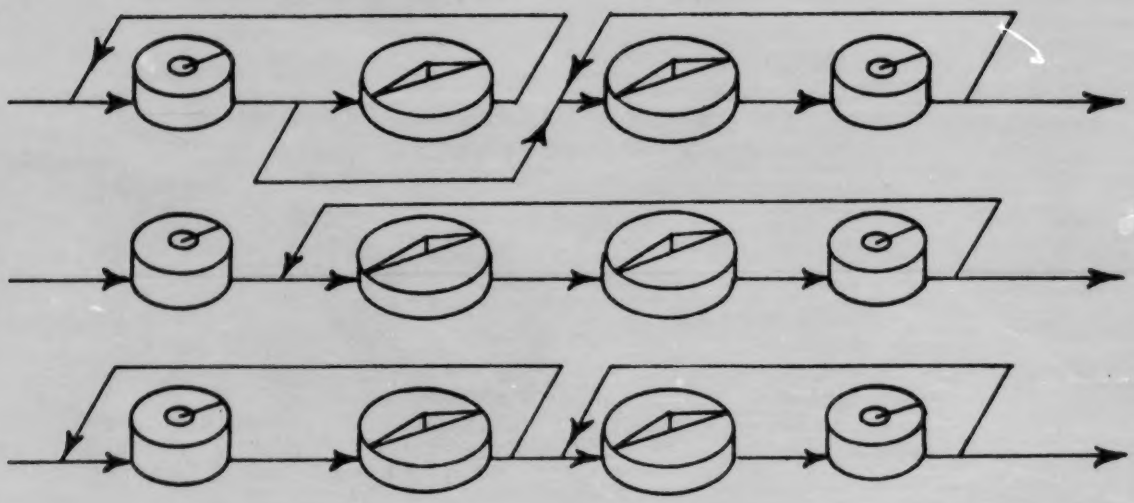
Week 7 Hour 1 (Con'd) Chapter: 6 Trickling Filters	
Lesson Outline	**Lecture Notes**
growth of organisms on the filter media is crucial to successful operation. 2. Trickling of water being treated over media 3. Decomposition of wastes 4. Recirculation 5. Efficiency of process 6. Temperature 6.1 Classification of Filters 6.10 General 1. Hydraulic loading, gpd/sq.ft. 2. Organic loading, lbs BOD/day/ 1000 cu. ft. of filter media 6.11 Standard-rate filters 1. Hydraulic loadings, 25 to 100 gpd/sq. ft. 2. Organic(BOD)loadings, 5 to 25 lbs BOD/day/1000 cu. ft. of filter media 3. Depth, 6 to 8 feet 6.12 High-rate filters 1. Hydraulic loadings, 100 to 1000 gpd/sq. ft.	

Week 7	Hour 1 (Con'd)	Chapter: 6 Trickling Filters

Lesson Outline	Lecture Notes
2. Organic (BOD) loadings, 25 to 300 lbs BOD/day/1000 cu. ft. of filter media 3. Depth, 3 to 5 feet 6.13 Roughing Filters Organic loadings over 300 lbs BOD/day/1000 cu. ft. of filter media 6.14 Filter Staging (Refer to Fig. 19, recirculation patterns) 6.2 Starting, Operating and Shutting Down a Filter 6.20 Pre-start up 1. Pre-start up inspections can avoid frustrating and costly delays. 2. Structure and channels 3. Distributor 4. Pumps 5. Valves 6.21 Placing Filter in Service 1. Starting wastewater flowing	



Typical Single-Stage Recirculation Patterns



Typical Two-Stage Recirculation Patterns

Fig. 19, Trickling filter recirculation patterns

Week 7 Hour 1 (Con'd) Chapter: 6 Trickling Filters	
Lesson Outline	Lecture Notes
2. Developing slime growths 6.22 Daily Operation 1. Ponding 2. Filter flies 3. Odors 4. Plugged orifices 5. Roughness or vibration of distributor arms 6. Leakage past seal 7. Recirculation 8. Hydraulic loading 6.23 Shut Down of a Filter 1. Inflow 2. Impact on other treatment processes in plant. 3. Tools and equipment needed 4. Work on other equipment while filter out of service 5. Procedures 6.3 Sampling and Analysis 6.30 Important Considerations 6.31 Typical Trickling Filter Plant Lab Results	

Week 7 Hour 1 (Con'd) Chapter: 6 Trickling Filters	
Lesson Outline	**Lecture Notes**
6.32 Response to Poor Trickling Filter Performance 1. High suspended solids in effluent 2. High BOD in effluent 3. High settleable solids in effluent 4. Low dissolved oxygen (DO) in effluent 5. High chlorine demand 6. Poor clarity 7. High coliform counts	

Week 7	Hour 2	Chapter:	6 Trickling Filters

Lesson Outline	Lecture Notes
Objectives: Refer to objectives listed in Chapter 6, Trickling Filters Lecture Outline 6.4 Operational Strategy 1. Treat daily fluctuations 2. Be prepared to handle shock loads (Hydraulic, organic and toxic). 6.40 Daily Operating Procedures 1. Use the lowest recirculation rates that will produce good results (meet NPDES permit requirements) but not cause ponding or other problems. Low recirculation rates conserve energy and minimize plant operating costs. 2. Daily routine observations 3. Measure and record all important process factors 4. Loading parameters 5. Plant effluent 6. Trend charts 7. Seasonal changes 6.41 Response to Abnormal Conditions	

Week 7 Hour 2 (Con'd) Chapter: 6
Trickling Filters

Lesson Outline	Lecture Notes
1. Ponding 2. Odors 3. Filter flies 4. Weather problems 5. Plant inflow a. Storm water infiltration b. Broken collection system pipe c. Clearance of main line sewer stoppage d. Industrial discharges 6. Operational problems with upstream or downstream treatment processes a. Screening b. Grit c. Primary clarifier d. Secondary clarifier e. Chlorinator 6.42 Trouble-shooting 6.5 Maintenance 6.50 Bearings and seals 6.51 Distributor arms	

Week 7 Hour 2 (Con'd) Chapter: 6 Trickling Filters	
Lesson Outline	**Lecture Notes**
6.52 Fixed nozzles 6.53 Underdrains	

Week 7	Hour 3	Chapter: 6 Trickling Filters

Lesson Outline	Lecture Notes
Objectives: Refer to objectives listed in Chapter 6, Trickling Filters	
Lecture Outline	
6.7 Loading Parameters	
6.70 Typical loading rates	
1. Standard-rate filter	
2. High-rate filter	
6.71 Computing hydraulic loading	
Hydraulic loading, gpd/sq. ft. = Flow Rate, gpd / Surface Area, sq.ft.	
1. Calculate hydraulic loading	
2. Evaluation and discussion of hydraulic loading	
6.72 Computing Organic (BOD) Loading	
Organic (BOD) Loading, lbs BOD/day/1000 cu.ft. = BOD Applied, lbs/day / Vol. of Media in 1000 cu.ft.	
BOD Applied, lbs/day = Flow, MGD x BOD, mg/l x 8.34 lbs/gal	
1. Calculate organic (BOD) loading	
2. Evaluation and discussion of organic (BOD) loading.	
6.73 Typical Loading Rates (metric, 2nd Ed.)	
6.74 Computing hydraulic loading (metric, 2nd Ed.)	

Week 7 Hour 3 (Con'd) Chapter: 6 Trickling Filters	
Lesson Outline	Lecture Notes
6.75 Computing organic (BOD) loading (metric, 2nd Ed.) 6.8 Review of Plans and Specifications Purpose: a. Become familiar with proposed plant from the plans and specs. b. Learn what will be constructed c. Offer suggestions on how plant can be designed for easier and more effective operation and maintenance. 1. Site 2. Trickling filter structure 3. Equipment 4. Safety	

Week 7	3-Hour Lab (Optional)	Chapter: 6 Trickling Filters

Lesson Outline	Lecture Notes
Objectives: Visit a trickling filter plant and observe or help (if possible) the operator operate and maintain a trickling filter. NOTE: If a trickling filter plant is not available, you may wish to repeat last week's lab on primary clarifiers at a different treatment plant.	

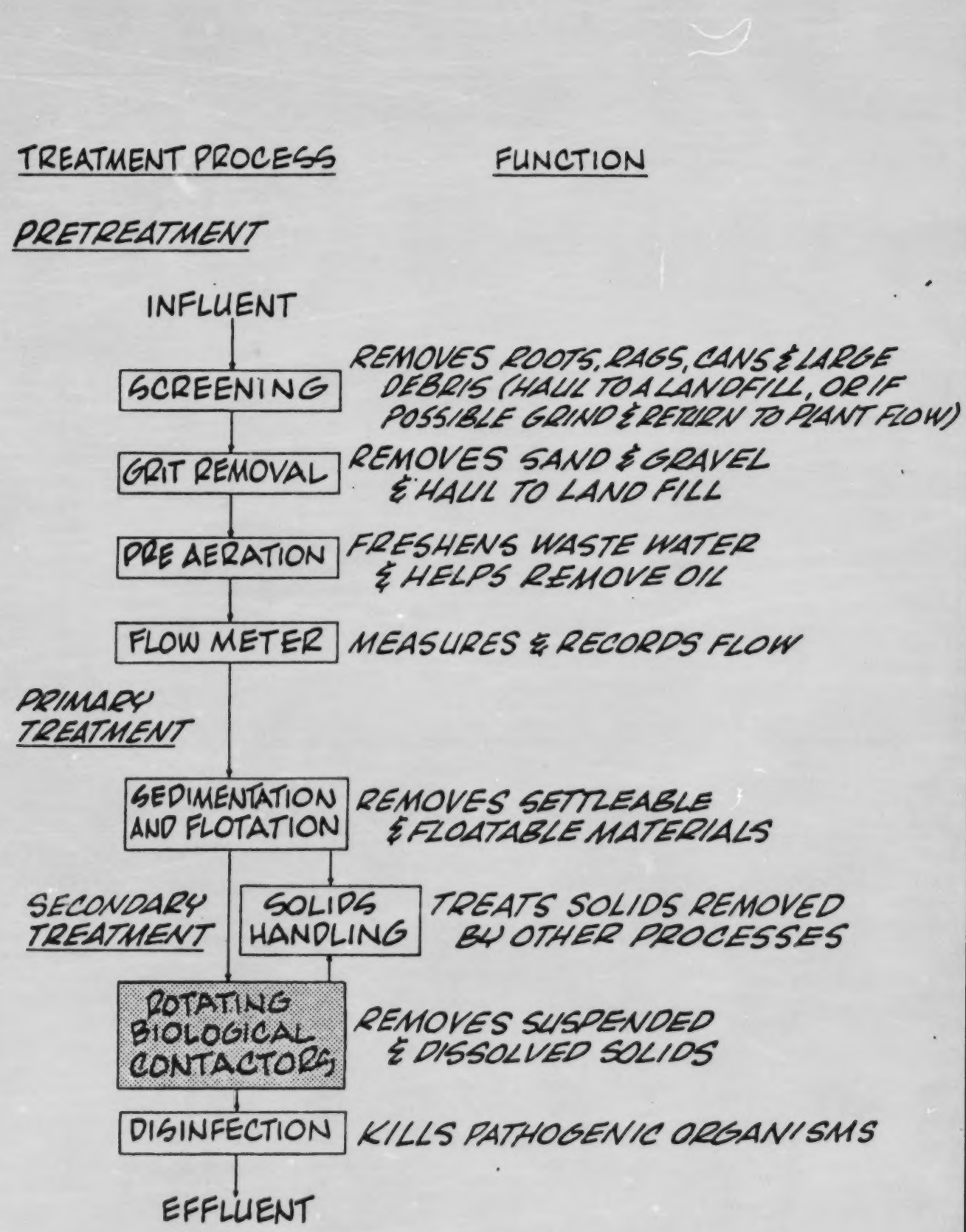
CHAPTER 7

ROTATING BIOLOGICAL CONTACTORS
(Second Edition)

Week 8	Hour 1	Chapter: 7 Rotating Biological Contactors (Second Edition)

Lesson Outline	Lecture Notes
Objectives: Refer to objectives listed at the beginning of Chapter 7, Rotating Biological Contractors (SECOND EDITION ONLY) NOTE: You may wish to expand time spent on covering trickling filters and reduce time spent on rotating biological contactors. Some instructors may wish to discuss anaerobic sludge digesters and sand drying beds now instead of during the second semester in Wastewater Treatment II. Assignment: Discussion and review questions at end of the lessons and the objective test at end of Chapter 7 (Second Edition Only). Lecture Outline Glossary: Review new words 7.0 Description of Rotating Biological Contactors. 1. Purpose: Remove organic matter from domestic and industrial wastes. 2. Describe how process works: a. Inflow b. Plastic disc media c. Effluent	

Lesson Outline	Lecture Notes
3. Typical plant (Refer to Fig. 21) 4. Purpose of components of a rotating biological contactor (Refer to Table 7.1, 2nd Ed.). 5. Staging (Refer to Fig. 22) 6. Covers 7. Drive assemblies 7.1 Process Operation 1. Performance affected by hydraulic loadings and temperatures below 55 degrees F (13 degrees C) 2. No problems with ponding like trickling filters 7.10 Pretreatment requirements Screening, grit removal, primary settling. 7.11 Start-up 1. Tightness 2. Lubrication 3. Clearance 4. Safety 5. Procedures	


TREATMENT PROCESS
FUNCTION
PRETREATMENT
INFLUENT
SCREENING
REMOVES ROOTS, RAGS, CANS & LARGE DEBRIS (HAUL TO A LANDFILL, OR IF POSSIBLE GRIND & RETURN TO PLANT FLOW)
GRIT REMOVAL
REMOVES SAND & GRAVEL & HAUL TO LAND FILL
PRE AERATION
FRESHENS WASTE WATER & HELPS REMOVE OIL
FLOW METER
MEASURES & RECORDS FLOW
PRIMARY TREATMENT
SEDIMENTATION AND FLOTATION
REMOVES SETTLEABLE & FLOATABLE MATERIALS
SECONDARY TREATMENT
SOLIDS HANDLING
TREATS SOLIDS REMOVED BY OTHER PROCESSES
ROTATING BIOLOGICAL CONTACTORS
REMOVES SUSPENDED & DISSOLVED SOLIDS
DISINFECTION
KILLS PATHOGENIC ORGANISMS
EFFLUENT

136

Fig. 20

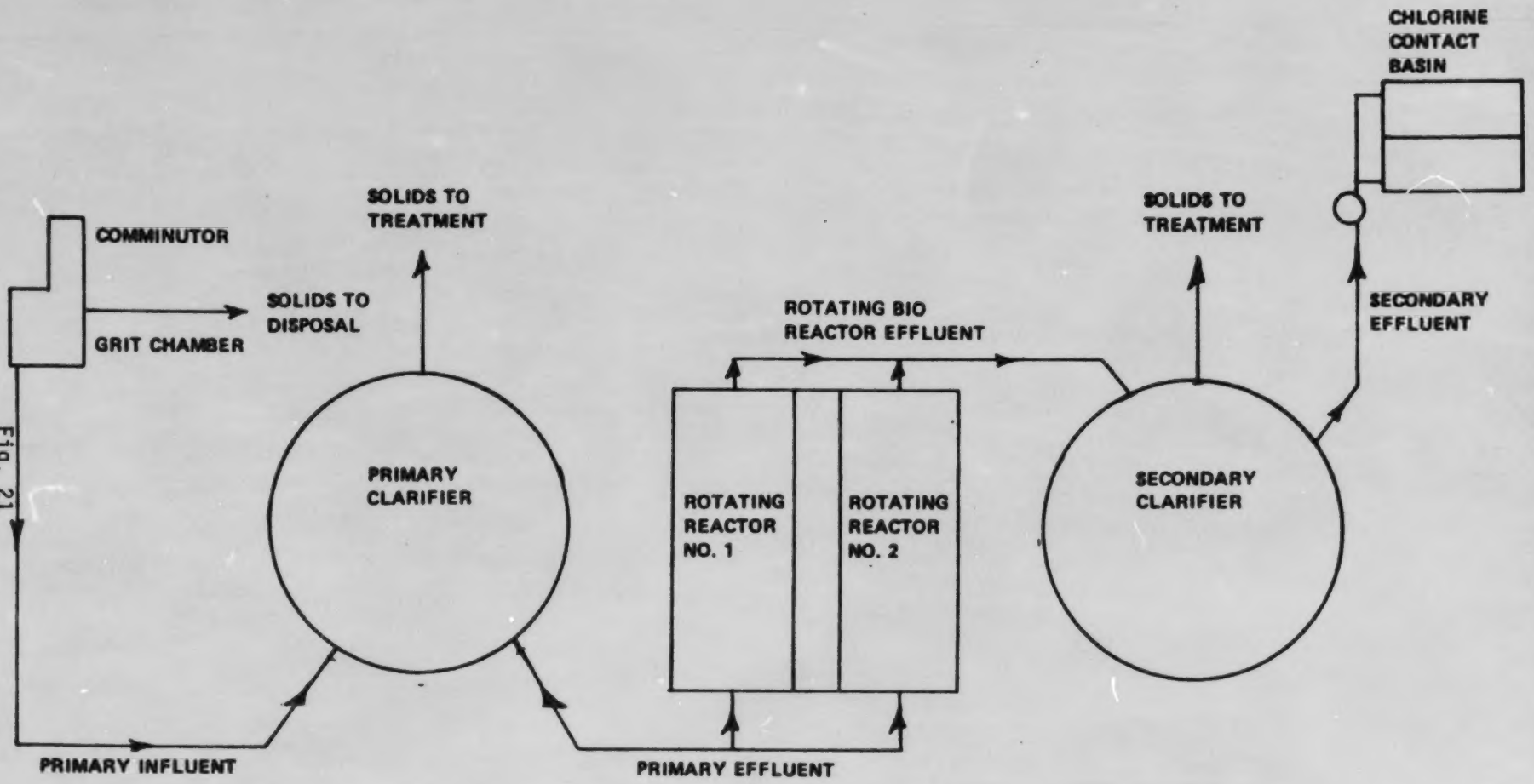
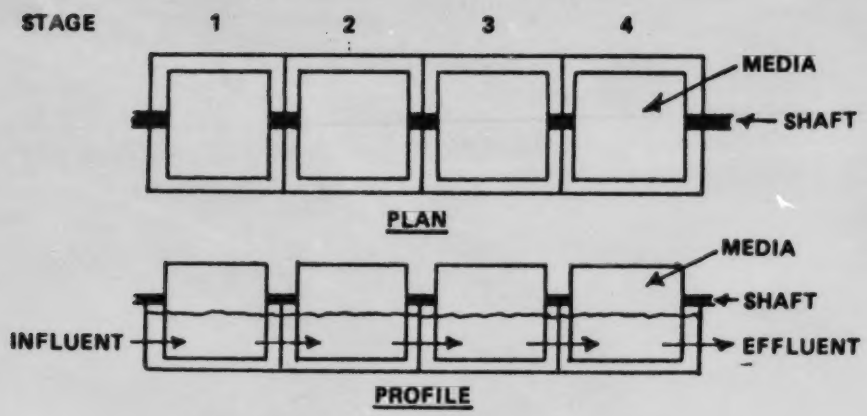
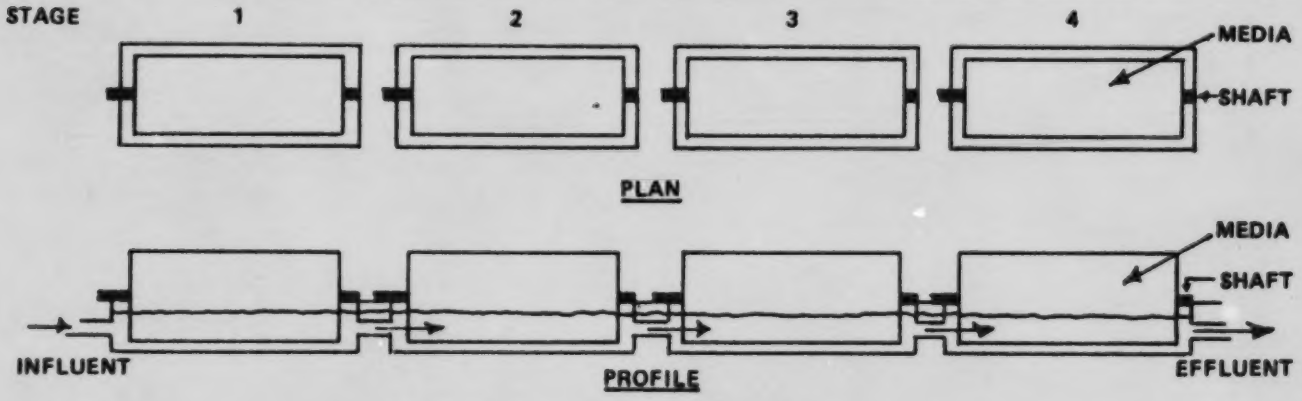


Fig. 21
98

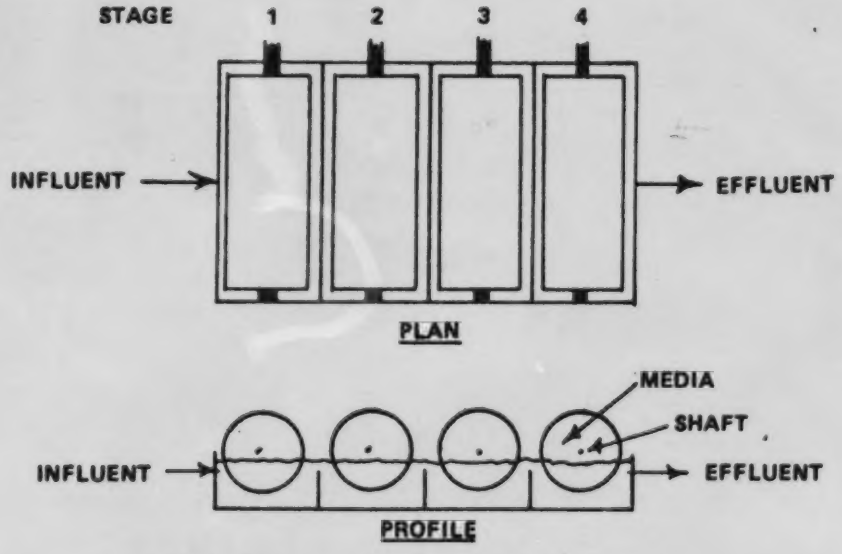
Typical rotating biological contactor treatment plant



LAYOUT NO. 1 ONE SHAFT, FOUR STAGES
FLOW PARALLEL TO SHAFT



LAYOUT NO. 2 FOUR SHAFTS, FOUR STAGES
FLOW PARALLEL TO SHAFT



LAYOUT NO. 3 FOUR SHAFTS, FOUR STAGES
FLOW PERPENDICULAR TO SHAFT

Fig. 22 Possible rotating biological contactor layouts

Week 8	Hour 1 (Con'd)	Chapter: 7 Rotating Biological Contactors (Second Edition)

Lesson Outline	Lecture Notes
7.12 Operation	
1. Inspecting equipment	
2. Testing influent and effluent	
3. Observing the media	
7.13 Abnormal operation	
1. High or low flows	
2. High or low solids loadings	
3. Power outage	
7.14 Shut-down and restart	

Week 8	Hour 2	Chapter: 7 Rotating Biological Contactors (Second Edition)

Lesson Outline	Lecture Notes
Objectives: Refer to objectives listed at beginning of Chapter 7, Rotating Biological Contactors (SECOND EDITION ONLY). Lecture Outline 7.2 Maintenance 1. Manufacturers' instructions 2. Plant O&M manual 3. Preventive maintenance 7.20 Break-in Maintenance 1. After 8 hours of operation 2. After 24 hours operation 3. After 100 hours operation 4. After 3 weeks operation 7.21 Preventive maintenance program 1. Daily 2. Weekly 3. 4 weeks 4. 3 months 5. 6 months 6. 12 months 7.22 Housekeeping 7.23 Trouble-shooting 1. Roller chain drive 2. Belt drive	

Week 8	Hour 3	Chapter: 7 Rotating Biological Contactors

Lesson Outline	Lecture Notes
Objectives: Refer to objectives listed at beginning of Chapter 7, Rotating Biological Contactors (SECOND EDITION ONLY). Lecture Outline 7.3 Safety 1. Moving parts 2. Electrical equipment 3. Slippery surfaces 4. Personal hygiene 7.4 Review of plans and specifications 1. Enclosure or cover 2. Heating Use remaining available time for catch up or review.	

Week 8	3-Hour Lab (Optional)	Chapter: 7 Rotating Biological Contactors

Lesson Outline	Lecture Notes
Objective: Visit a rotating biological contactor plant and observe or help (if possible) the operator operate and maintain a rotating biological contactor. NOTE: If a rotating biological contactor is not available, select an appropriate plant to visit and help the operator with some aspect of maintenance and operation.	

Week 9	Hour 1	Chapter: 5 through 7

Lesson Outline	Lecture Notes
Objective: Review for Exam II 1. Cover important material since last exam. 2. Emphasize purpose of processes, equipment and components. 3. Discuss start-up, normal and abnormal operation, and shut down of processes and equipment. 4. Outline maintenance procedures. 5. Review safety hazards and safe procedures. 6. Identify important items that should be considered when reviewing plans and specifications. 7. Outline trouble-shooting procedures.	

Week 9	Hour 2	Chapter: 5 through 7

Lesson Outline	Lecture Notes
Objective: Exam II	

Week 9 **Hour** 3 **Chapter:** 5 through 7

Lesson Outline	Lecture Notes
Objectives: 1. Review results of Exam II and correct all mistakes or errors. 2. Identify areas for future review and students who need additional help. NOTE: 1. If Exam II is not graded, continue on to Week 10, Hour 1, and review exam when available. 2. Some instructors may wish to schedule exams less frequently or more frequently and should feel free to do so.	

Week 9 3-Hour Lab (Optional) Chapter:

Lesson Outline	Lecture Notes
Suggest instructor schedule visit to treatment plant where operator may need help with a maintenance or repair job.	

CHAPTER 7

ACTIVATED SLUDGE

(First Edition)

or

CHAPTER 8

ACTIVATED SLUDGE

(Second Edition)

Week 10	Hour 1	Chapter:	7, Activated Sludge (First Edition) or 8, Activated Sludge (Second Edition) Part 1, Package Plants and Oxidation Ditches

Lesson Outline

Objectives: Refer to the objectives listed at the beginning of:

1. Chapter 7, Activated Sludge (First Edition)

or

2. Chapter 8, Activated Sludge, Part I, Package Plants and Oxidation Ditches (Second Edition).

Assignment: Discussion and review questions at end of lesson and objective test (appropriate portions), Chapter 7, (First Edition), or Chapter 8 (Second Edition).

Lecture Outline

Glossary: Review new words

8.0* The Activated Sludge Process.

Process treats wastewater from:

1. Primary clarifier (most common); or
2. Raw wastewater.
3. Refer to flow diagram of treatment processes.

* Numbers for Second Edition: Subtract 1.0 for first edition, 7.0. The Activated Sludge Process.

Lecture Notes

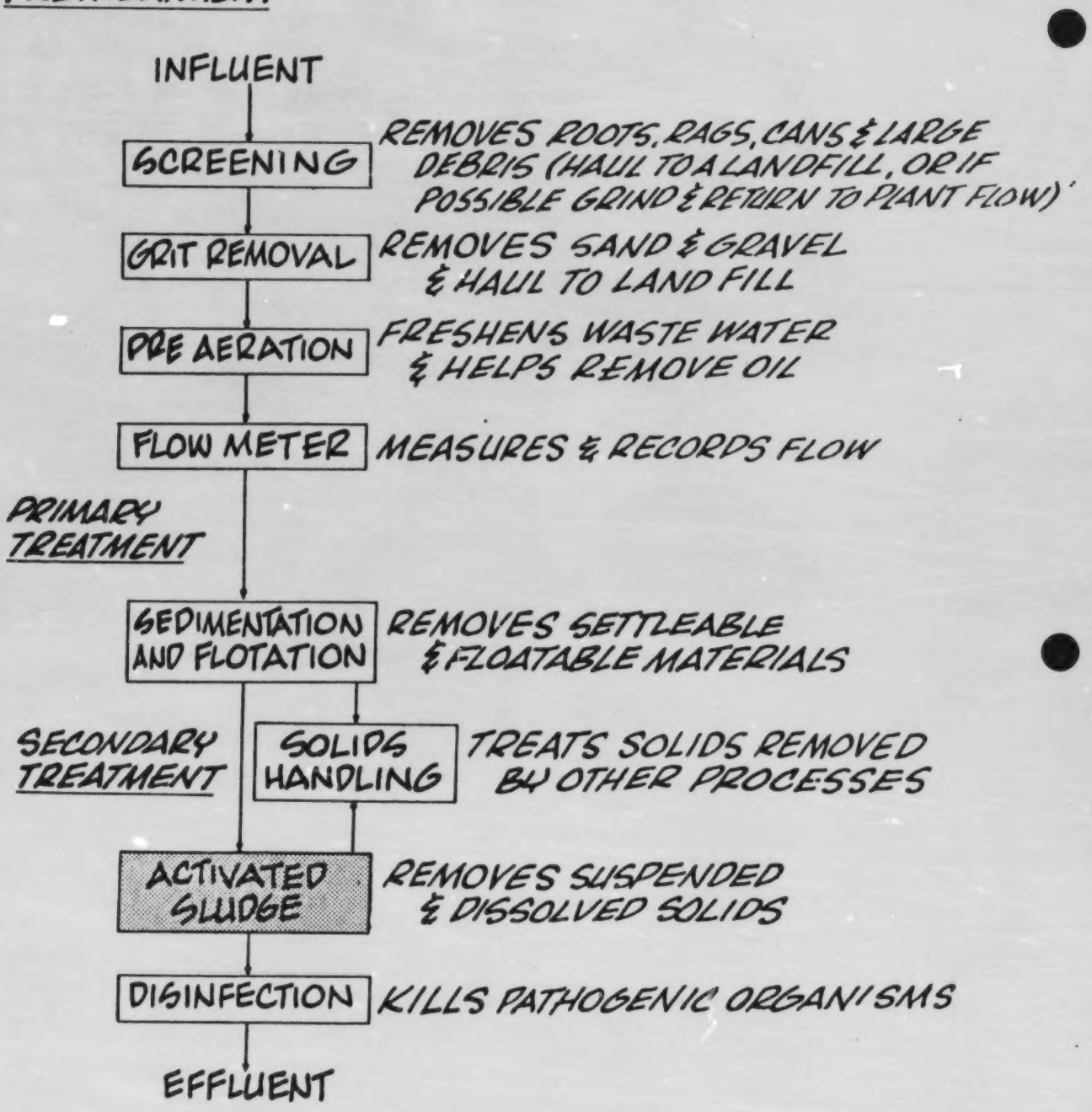

TREATMENT PROCESS
FUNCTION
PRETREATMENT
INFLUENT
SCREENING
REMOVES ROOTS, RAGS, CANS & LARGE DEBRIS (HAUL TO A LANDFILL, OR IF POSSIBLE GRIND & RETURN TO PLANT FLOW)
GRIT REMOVAL
REMOVES SAND & GRAVEL & HAUL TO LAND FILL
PRE AERATION
FRESHENS WASTE WATER & HELPS REMOVE OIL
FLOW METER
MEASURES & RECORDS FLOW
PRIMARY TREATMENT
SEDIMENTATION AND FLOTATION
REMOVES SETTLEABLE & FLOATABLE MATERIALS
SECONDARY TREATMENT
SOLIDS HANDLING
TREATS SOLIDS REMOVED BY OTHER PROCESSES
ACTIVATED SLUDGE
REMOVES SUSPENDED & DISSOLVED SOLIDS
DISINFECTION
KILLS PATHOGENIC ORGANISMS
EFFLUENT

Fig. 23

Week 10 Hour 1 (Con'd) Chapter:	7, Activated Sludge (First Edition) or 8, Activated Sludge (Second Edition) Part 1
Lesson Outline	**Lecture Notes**
8.01 Definitions 1. Activated sludge 2. Activated sludge process 8.02 Process Description 1. Purpose: Oxidation and removal of soluble or finely divided suspended materials that were not removed by previous treatment 2. Materials removed by aerobic organisms within a few hours when the water is being treated while it flows through the aeration tank. 3. Liquid-organism (water-solids) separation occurs in a secondary clarifier after aeration. 4. Clarifier effluent is usually chlorinated prior to discharge to receiving waters. 5. Clarifier effluent may receive additional treatment	

Week 10 Hour 1 (Con'd) Chapter:	7, Activated Sludge (First Edition) or 8, Activated Sludge (Second Edition) Part 1
Lesson Outline	**Lecture Notes**
prior to chlorination depending on uses of receiving water or if wastewater is reclaimed for some use.	

152

Week 10	Hour 2	Chapter: 7, Activated Sludge (First Edition) or 8, Activated Sludge (Second Edition) Part I

Lesson Outline	Lecture Notes
Objectives: Refer to objectives listed at the beginning of: 1. Chapter 7, Activated Sludge (First Edition); or 2. Chapter 8, Activated Sludge, Part I, Package Plants and Oxidation Ditches (Second Edition). Lecture Outline 8.1 Requirements for Control 1. Effluent quality requirements a. NPDES Permit b. BOD c. Suspended solids d. Settleable solids e. Coliform group bacteria (MPN) 2. Wastewater flow, waste concentrations, and characteristics a. Municipal ordinances b. Control or monitoring of industries 3. Amount of activated sludge (containing the working organisms) to be maintained in the process	

Lesson Outline	Lecture Notes
relative to inflow. a. Organism competition for food b. Food to Microorganism (F/M) ratio is a primary control in the activated sludge process. c. Organisms tend to increase with waste (food) load and time spent in the aeration tank. 4. Under favorable conditions the operator will remove (sludge wasting) the excess organisms to maintain the required number of "workers" for effective waste treatment. Therefore, the removal of organisms from the treatment process (sludge wasting) is a very important control technique. 5. Sufficient oxygen is necessary to sustain the living organisms for the oxidation of wastes to obtain energy for growth. Either insufficient oxygen or excess oxygen	

Week 10 Hour 2 (Con'd)	Chapter: 7, Activated Sludge (First Edition) or 8, Activated Sludge (Second Edition) Part I
Lesson Outline	**Lecture Notes**
can cause operating problems. 6. Flows must be divided evenly among two or more treatment units. 7. Activated sludge solids concentrations in the aerator and the secondary clarifier should be determined by the operator for control purposes. The activated sludge solids in the aerator indicate the microorganisms that are available to treat the incoming wastes. Settleability tests of the mixed liquor from the clarifier show the degree and volume of solids settling that may be obtained in a secondary clarifier. A visual examination of the secondary clarifier reveals what is actually happening. 8. Activated sludge tends to convert soluble solids to suspended cell mass material and to gather and	

Week 10	Hour 2 (Con'd)	Chapter:	7, Activated Sludge (First Edition) or 8, Activated Sludge (Second Edition) Part I

Lesson Outline	Lecture Notes
agglomerate particles too fine to settle rapidly into readily separated material. 9. There must be organisms, oxidizing conditions, and suitable time to cause the conversion of soluble solids and to agglomerate the fine particles to form a floc mass. 10. When a floc mass is returned to the aerator from the final clarifier, the organisms grow as a result of taking food from the inflowing wastewater. The surface of the floc mass is irregular and promotes the transfer of wastewater pollutants into the solids by means of mechanical entrapment, absorption, adsorption, or adhesion. 11. Material taken into the floc mass is partially oxidized to form cell mass and oxidation products. Mixing in the areator promotes collisions and thus produces larger floc mass.	

Week 10 Hour 2 (Con'd)	Chapter: 7, Activated Sludge (First Edition) or 8, Activated Sludge (Second Edition) Part I

Lesson Outline	Lecture Notes
12. Growth of organisms and accumulated residues produce solids for disposal (waste activated sludge). Maintain as high a concentration of solids in the return sludge as possible to reduce the amount of water needed to return these solids back to the aerator. 13. Don't pump waste activated sludge directly to an anaerobic digester because it will return to the aeration tank as supernatant with an added load on the organisms. Pump waste activated sludge to influent of primary clarifiers or sludge thickeners. 14. To maintain the working organisms in the activated sludge, <u>you must</u> provide a suitable environment. Intolerable concentrations of acids, bases, and other toxic substances are undesirable and may kill the working organisms.	

Week 10	Hour 2 (Con'd)	Chapter: 7, Activated Sludge (First Edition) or 8, Activated Sludge (Second Edition) Part I

Lesson Outline	Lecture Notes
Unduly fluctuating loads may cause overfeeding, starvation, and other factors that are all capable of upsetting the activated sludge process. Insufficient oxygen can cause an unfavorable environment which results in decreased organism activity. 15. Control of the activated sludge process consists of maintaining the proper solids (floc mass) concentration in the aerator for the waste (food) inflow by adjusting the waste sludge pumping rate and regulating the oxygen supply to maintain a satisfactory level of dissolved oxygen in the process.	

Week 10	Hour 3	Chapter: 7, Activated Sludge (First Edition) or 8, Activated Sludge (Second Edition) Part I

Lesson Outline	Lecture Notes
Objectives: 1. Review material covered during last 2 hours to thoroughly understand how the activated sludge process works. 2. Use remaining time in hour to catch up or to move ahead and start material on package plants.	

Week 10 3-Hour Lab (Optional)	Chapter: 7, Activated Sludge (First Edition) or 8, Activated Sludge (Second Edition) Part I
Lesson Outline	**Lecture Notes**
Objective: Visit an activated sludge plant and observe or help (if possible) the operator operate and maintain the activated sludge process.	

Week 11	Hour 1	Chapter: 7, Activated Sludge (First Edition) or 8, Activated Sludge (Second Edition) Part I

Lesson Outline	Lecture Notes
Objectives: Refer to objectives listed at the beginning of: 1. Chapter, 7, Activated Sludge (First Edition) or 2. Chapter 8, Activated Sludge, Part I, Package Plants and Oxidation Ditches (Second Edition) Assignment: Discussion and review questions at end of lesson on package aeration plants. Lecture Outline 8.2 Package Plants 8.20 Purpose of Package Plants 8.200 Use of Package Plants 1. Operation of small package plants is similar to the operation of any other activated sludge plant. 2. A high quality effluent requires attention, understanding, and good plant operation. 3. Two compartments or three compartments	

Week 11 Hour 1 (Con'd) Chapter: 7, Activated Sludge (First Edition) or 8, Activated Sludge (Second Edition) Part I	
Lesson Outline	Lecture Notes
8.201 Types of Package Plant Processes 1. Extended aeration 2. Contact stabilization 3. Complete mix 8.202 Aeration Methods 1. Mechanical aeration 2. Diffused aeration 8.21 Pre-start check-out While the tank is empty, check the following: 1. Tank must be level 2. If metal tank, cathodic protection required. 3. Condition of paint 4. Remove all rocks and debris 5. Check any preliminary treatment equipment (comminutor) 6. Inspect aeration device 7. Record and file important data 8. Check influent gate or valve for proper operation.	

Week 11 Hour 1 (Con'd)	Chapter: 7, Activated Sludge (First Edition) or 8, Activated Sludge (Second Edition) Part I

Lesson Outline	Lecture Notes
8.22 Starting the Plant 1. Fill tank 2. Start aeration equipment 3. Return flows to aeration tank 4. Foam control	

Week 11	Hour 2	Chapter: 7, Activated Sludge (First Edition) or 8, Activated Sludge (Second Edition) Part I

Lesson Outline

Objectives: Refer to the objectives listed at the beginning of:

1. Chapter 7, Activated Sludge (First Edition)

or

2. Chapter 8, Activated Sludge, Part I, Package Plants and Oxidation Ditches (Second Edition)

Lecture Outline

8.23 Operation of Aeration Equipment

1. Operate aeration equipment continuously. Good treatment rarely results from interrupted operation and should not be attempted. How would you like to be given too much air, just the right amount, and then not enough air? Do you think you could do a good job under these conditions?
2. If the water is murky or cloudy and the aeration compartment has a rotten egg

Lecture Notes

Lesson Outline	Lecture Notes
odor (H_2S), insufficient air is supplied and the air supplied or aeration rate should be increased. 3. If the water is clear in the settling compartment, the aeration rate is probably sufficient. 4. If you can measure the dissolved oxygen (DO) in the aeration tank, the DO should be around 2 mg/l <u>THROUGHOUT</u> the aeration tank (top and bottom, along sides and at both ends) 8.24 Wasting Sludge 1. Waste about 5 percent of the solids each week. 2. Allow solids to settle to bottom of settling compartment for about one hour. 3. Pump solids to a. Drying beds if odors are not a problem.	

Week 11 Hour 2 (Con'd) Chapter:	7, Activated Sludge (First Edition) or 8, Activated Sludge (Second Edition) Part I
Lesson Outline	Lecture Notes
b. An aerated holding tank for ultimate disposal at an approved sanitary landfill. c. A septic tank pumper's truck for disposal at an approved sanitary landfill. 4. Frequency and amount of wasting should be revised periodically on basis of performance of plant. You do not want an excessive amount of solids in your plant effluent. 5. A white, fluffy foam indicates low solids content in the aerator, while a brown, leathery foam suggests high solids concentration.	

Week 11	Hour 3	Chapter: 7, Activated Sludge, (First Edition) or 8, Activated Sludge, (Second Edition) Part I

Lesson Outline	Lecture Notes
Objectives: Refer to the objectives listed at the beginning of, 1. Chapter 7, Activated Sludge (First Edition) or 2. Chapter 8, Activated Sludge, Part I, Package Plant and Oxidation Ditches (Second Edition) Lecture Outline 8.25 Operation 8.250 Normal Operation 1. Items to check each day a. Visual b. Sound c. Feel equipment for vibrations and temperatures d. Smell for odors 8.251 Abnormal Operation 1. Toxic wastes such as pesticides, detergents, solvents or high or low pH levels. 2. Excessively high or low flows or solids (organic)	

Week 11	Hour 3 (Con'd)	Chapter:	7, Activated Sludge (First Edition) or 8, Activated Sludge (Second Edition) Part I

Lesson Outline	Lecture Notes
loadings.	
8.252 Trouble-shooting	
1. Solids in effluent	
2. Odors	
3. Foaming/frothing	
8.253 Shut Down	
1. Depends on type of plant	
2. Beware of high ground water levels that could float empty compartments	
8.26 Laboratory Testing	
1. Settling test	
2. Solids settle half way down	
3. Solids settle to bottom and come back up	
4. Other lab tests	
8.27 Safety	
1. Toxic gases	
2. Dangerous chemicals	
3. Electrical hazards	
4. If you must work alone, phone your office at regular intervals.	

Week 11 Hour 3 (Con'd) Chapter:	7, Activated Sludge (First Edition or 8, Activated Sludge (Second Edition Part I
Lesson Outline	**Lecture Notes**
8.28 Maintenance 1. Cleanliness 2. Equipment	

Week 11 3-Hour Lab (Optional)	Chapter: 7, Activated Sludge (First Edition) or 8, Activated Sludge (Second Edition) Part I
Lesson Outline	Lecture Notes
Objective: Visit a package activated sludge plant and observe or help (if possible) the operator operate and maintain the activated sludge process. If a package plant is not available, visit a conventional activated sludge plant.	

Week 12	Hour 1	Chapter: 7, Activated Sludge (First Edition) or 8, Activated Sludge (Second Edition) Part I

Lesson Outline

Objectives: Refer to the objectives at the beginning of Chapter 8, Activated Sludge, Part I, Package Plants and Oxidation Ditches (Second Edition)

Assignment: Discussion and review questions at end of lesson on oxidation ditches and objective test at end of Chapter 8 (Second Edition).

Lecture Outline

8.3 Oxidation Ditches (Second Edition)

8.30 Use of Oxidation Ditches

8.300 Flow path for oxidation ditches

1. Refer to figure showing oxidation ditch flow path
2. The oxidation ditch is a modified form of the activated sludge process and is usually operated in the extended aeration mode.
3. Principle components include oxidation ditch, brush rotor assembly, settling tank, return sludge pump, and excess sludge handling facilities.

Lecture Notes

Week 12 Hour 1 (Con'd) Chapter:	7, Activated Sludge (First Edition) or 8, Activated Sludge (Second Edition)
Lesson Outline	Lecture Notes
4. Purpose of components in an oxidation ditch (Refer to Table 8.1, Second Edition). 5. Describe how process works. 6. Disposal of effluent 7. BOD removals above 90% and as high as 98% 8.301 Description of Oxidation Ditches 1. Performance of ditches 2. Operational criteria 8.31 Safety 1. Safety is a "life-style" 2. Wear proper shoes, gloves and clothing 3. Avoid slippery surfaces and clean up spills 4. Keep area neat and uncluttered 5. Do not walk on top of oxidation ditch walls or you may fall into ditch.	

Week 12	Hour 2	Chapter: 7, Activated Sludge (First Edition) or 8, Activated Sludge (Second Edition) Part I

Lesson Outline

Objectives: Refer to the objectives listed at the beginning of Chapter 8, Activated Sludge, Part I, Package Plants and Oxidation Ditches (Second Edition)

Lecture Outline

8.32 Start up

1. Make certain that all mechanical equipment is operating properly.
2. Develop the proper microbial floc (activated sludge) in the oxidation ditch. This floc is essential for the plant to succeed in reducing the quantities of polluting materials in the wastewater.

8.320 Pre-start inspection

1. Inlet structure
2. Ditch structure
3. Rotor
4. Adjustable weir
5. Clarifier structure and components
6. Return sludge and waste sludge

Lecture Notes

Lesson Outline	Lecture Notes
systems. 7. Pumps and valves 8.321 Plant Start up 1. Fill ditch with water 2. Obtain healthy "seed" activated sludge 3. Color of MLSS 4. Allow depth of ditch to get as high as possible to retain microorganisms. 5. Chlorination of effluent 6. Wastewater testing procedures 7. DO in ditch 8. Time to reach stabilization 9. Following start up, when the plant has stabilized, the solids should settle rapidly in the clarifier leaving a clear, odorless and stable effluent. The solids should look like particles, golden to rich dark brown in color, with sharply defined edges.	

Week 12	Hour 3	Chapter: 7, Activated Sludge (First Edition) or 8, Activated Sludge (Second Edition) Part I

Lesson Outline

Objectives: Refer to the objectives listed at the beginning of Chapter 8, Activated Sludge, Part I, Package Plants and Oxidation Ditches (Second Edition)

Lecture Outline

8.33 Operation

8.330 Normal Operation

1. Food supply for the micro-organisms
2. DO levels (water level in ditches)
3. Environment
4. Treatment time
5. Water/solids separation
6. Observations
   a. Color
   b. Odor
   c. Clarity
   d. Records
   e. Plant Survey

8.331 Abnormal Operation

1. Motor
2. Gear reducer
3. Bearings

Lecture Notes

Week 12 Hour 3 (Con'd) Chapter:	7, Activated Sludge (First Edition) or 8, Activated Sludge (Second Edition) Part I
Lesson Outline	Lecture Notes
4. Environmental factors (temperature and precipitation) 5. Hydraulic and organic overloads 8.332 Shut down 1. Scheduling 2. Rotor 8.333 Trouble-shooting 1. See Section 8.252, Trouble-shooting, for package plants. 2. Floatables in final settling tank 8.34 Maintenance 1. General housekeeping 2. Equipment maintenance a. Motors b. Gear reducer c. Bearings d. Lubrication 8.35 Operational criteria (both English and Metric Systems) 1. Oxidation ditch dimensions 2. Flow and waste characteristics 3. Oxidation ditch volume	

Week 12 Hour 3 (Con'd) Chapter:	7, Activated Sludge (First Edition) or 8, Activated Sludge (Second Edition) Part I
Lesson Outline	Lecture Notes
4. BOD loading 5. Food/microorganism ratio 6. Sludge age 7. Ditch detention time	

Week 12	3-Hour Lab (Optional)	Chapter: 7, Activated Sludge (First Edition) or 8, Activated Sludge (Second Edition) Part I

Lesson Outline	Lecture Notes
Objective: Visit an oxidation ditch plant and observe or help (if possible) the operator operate and maintain the oxidation ditch. If an oxidation ditch is not available, visit an activated sludge plant.	

CHAPTER 9

WASTE TREATMENT PONDS

Week 13	Hour 1	Chapter: 9 Waste Treatment Ponds

Lesson Outline	Lecture Notes
Objectives: Refer to the objectives listed at the beginning of Chapter 9, Waste Treatment Ponds. Assignment: Discussion and review questions at the end of each lesson and the objective test at the end of Chapter 9. Lecture Outline Glossary: Review new words 9.1 Use of Ponds 1. Treatment of wastewater instead of conventional waste treatment processes 2. Treatment of wastewater in addition to (after) conventional waste treatment processes. 3. Breakdown of wastes 4. Typical pond layout (Refer to Figures 24 and 25) 5. Purpose of pond components (Refer to Table 9.1, Second Edition) 9.2 History of Ponds in Waste Treatment 1. Early uses 2. Advantages for smaller installations	

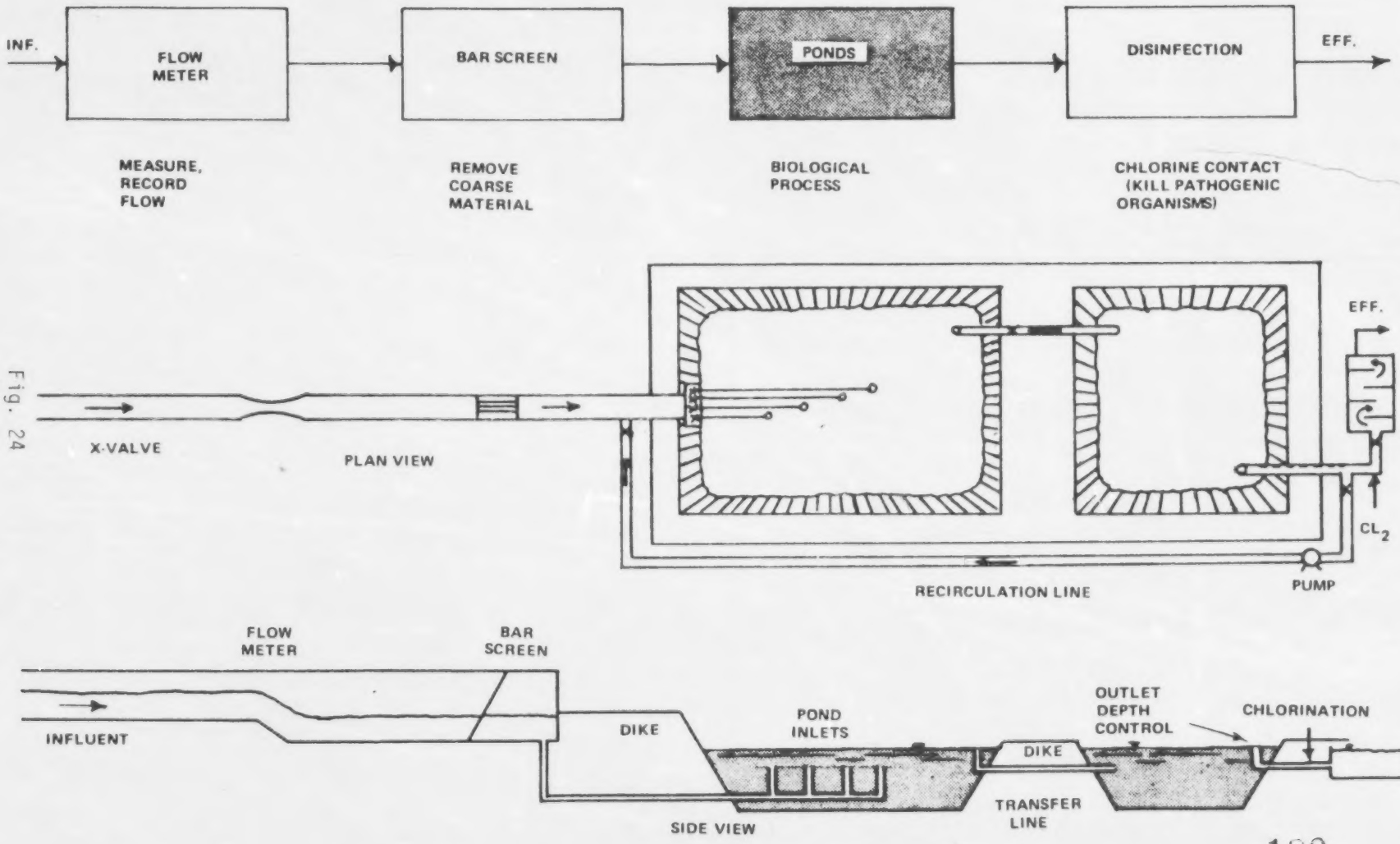


Fig. 24
139

181

182

Typical plant; ponds only

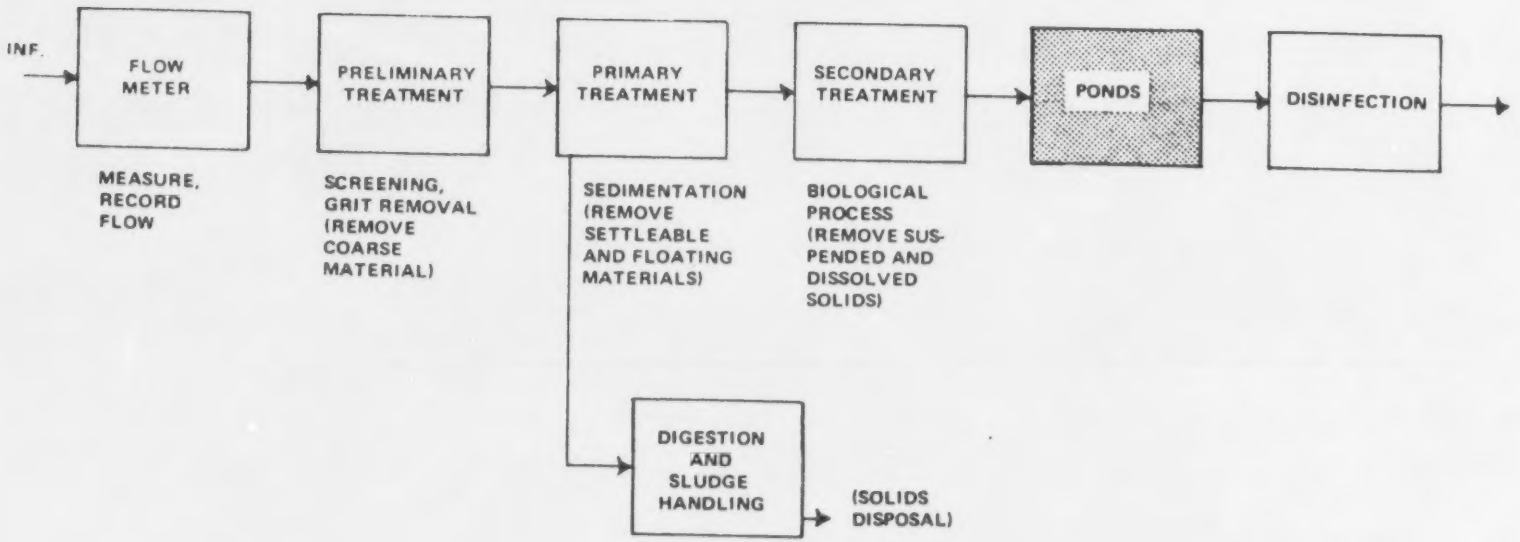
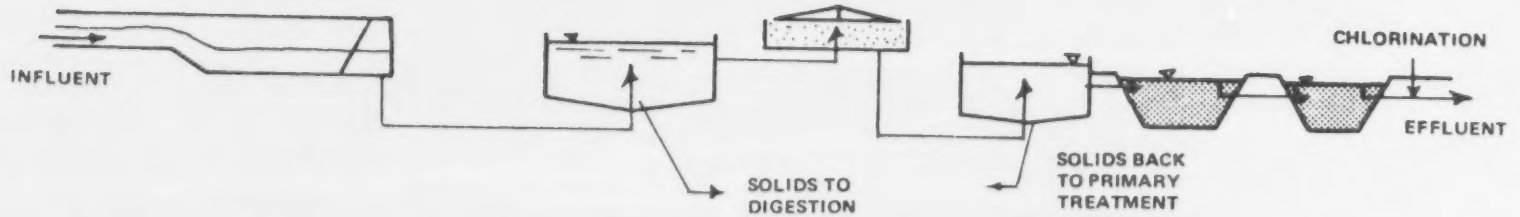


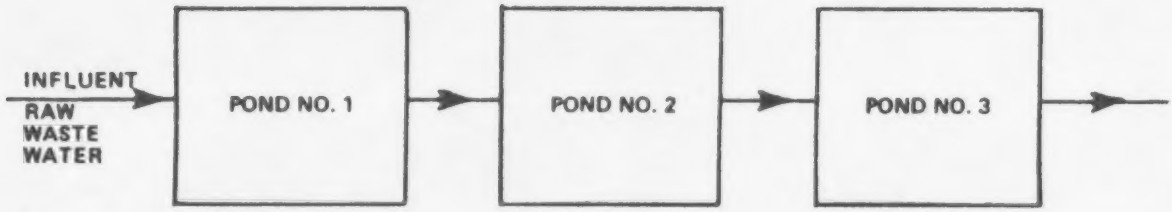
Fig. 25



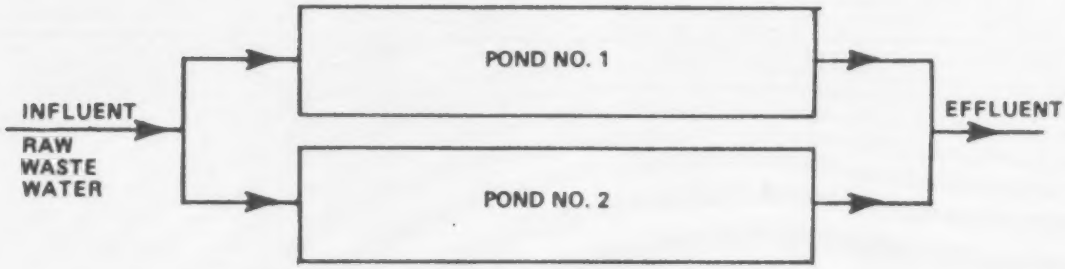
Typical plant; ponds after secondary treatment

Week 13 Hour 1 (Con'd) Chapter: 9
Waste Treatment Ponds

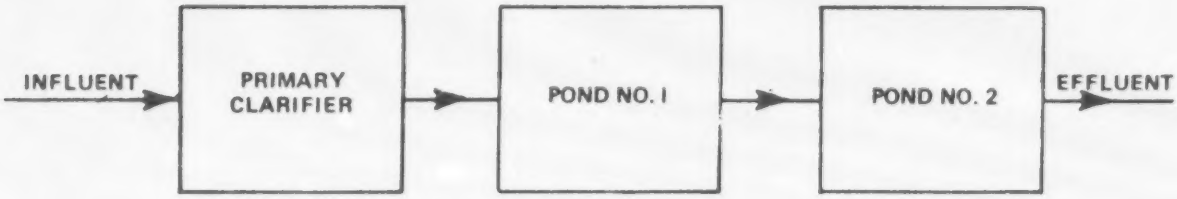
Lesson Outline	Lecture Notes
9.3 Pond Classifications and Applications (Refer to Fig. 26) 1. Raw wastewater lagoon or stabilization ponds 2. Oxidation ponds 3. Polishing ponds 4. Aerobic, anaerobic and facultative ponds 9.4 Explanation of Treatment Process (Refer to Fig. 27) 1. Role of algae 2. Production of oxygen 3. Anaerobic ponds or anaerobic layer 4. Sludge decomposition and storage 5. Methane fermentation 9.5 Pond Performance 1. Physical factors 2. Chemical factors 3. Biological factors 4. Treatment efficiencies 5. Detention times	



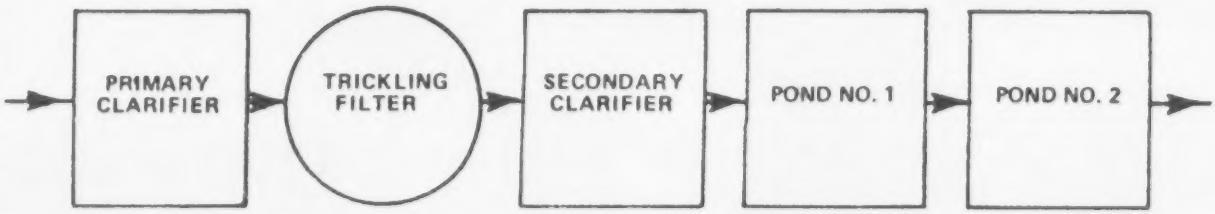
STABILIZATION PONDS IN SERIES



STABILIZATION PONDS IN PARALLEL



OXIDATION PONDS IN SERIES



POLISHING PONDS IN SERIES

Fig. 26, Pond Classifications

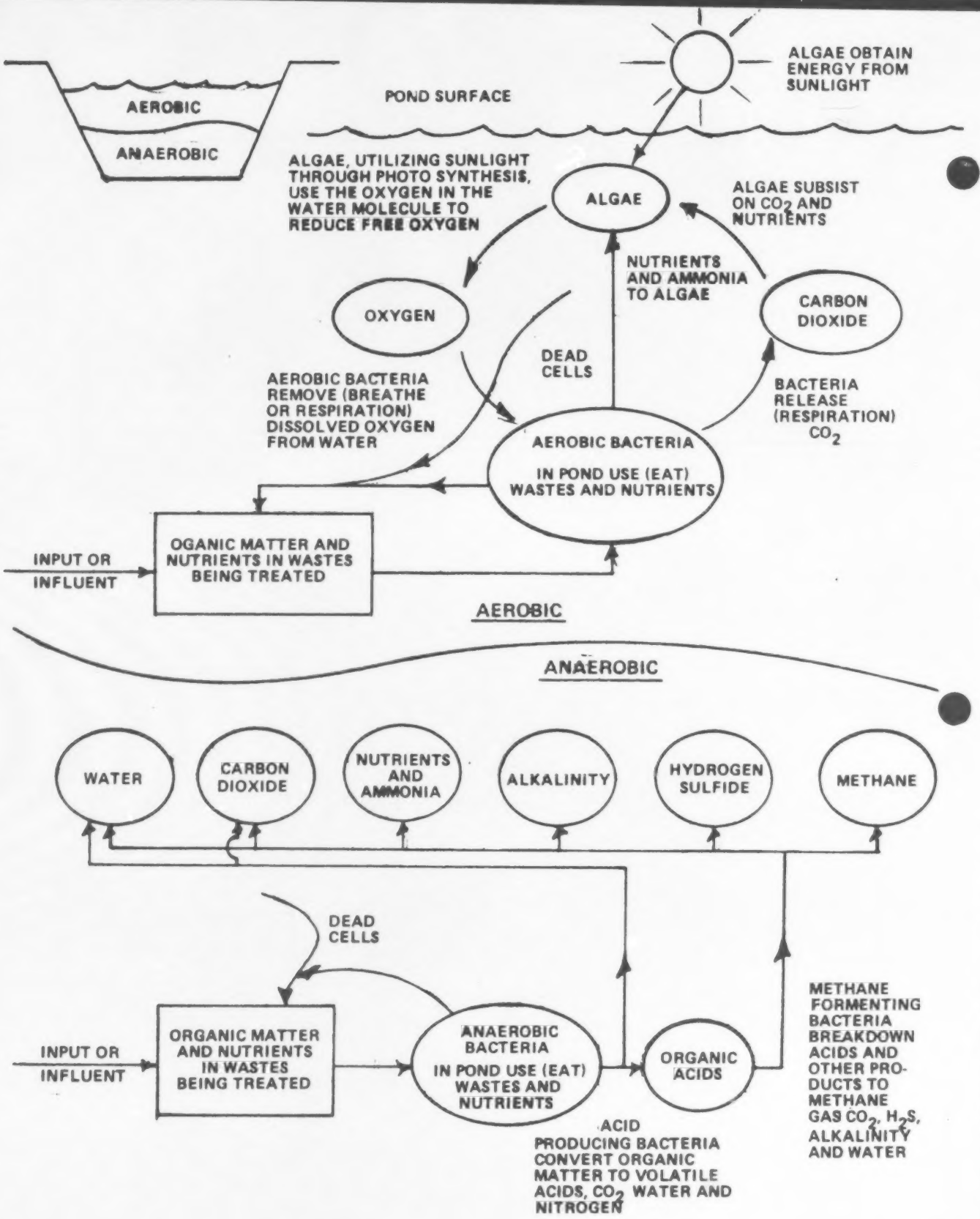

AEROBIC
ANAEROBIC
POND SURFACE
ALGAE OBTAIN ENERGY FROM SUNLIGHT
ALGAE, UTILIZING SUNLIGHT THROUGH PHOTO SYNTHESIS, USE THE OXYGEN IN THE WATER MOLECULE TO REDUCE FREE OXYGEN
ALGAE
ALGAE SUBSIST ON CO_2 AND NUTRIENTS
NUTRIENTS AND AMMONIA TO ALGAE
OXYGEN
CARBON DIOXIDE
DEAD CELLS
AEROBIC BACTERIA REMOVE (BREATHE OR RESPIRATION) DISSOLVED OXYGEN FROM WATER
BACTERIA RELEASE (RESPIRATION) CO_2
AEROBIC BACTERIA IN POND USE (EAT) WASTES AND NUTRIENTS
INPUT OR INFLUENT
OGANIC MATTER AND NUTRIENTS IN WASTES BEING TREATED
AEROBIC
ANAEROBIC
WATER
CARBON DIOXIDE
NUTRIENTS AND AMMONIA
ALKALINITY
HYDROGEN SULFIDE
METHANE
DEAD CELLS
INPUT OR INFLUENT
ORGANIC MATTER AND NUTRIENTS IN WASTES BEING TREATED
ANAEROBIC BACTERIA IN POND USE (EAT) WASTES AND NUTRIENTS
ORGANIC ACIDS
METHANE FORMENTING BACTERIA BREAKDOWN ACIDS AND OTHER PRODUCTS TO METHANE GAS CO_2, H_2S, ALKALINITY AND WATER
ACID PRODUCING BACTERIA CONVERT ORGANIC MATTER TO VOLATILE ACIDS, CO_2 WATER AND NITROGEN

Fig. 27 Process of decomposition in aerobic and anaerobic layers of a pond

143

Week 13	Hour 2	Chapter: 9 Waste Treatment Ponds

Lesson Outline	Lecture Notes
Objectives: Refer to the objectives listed at the beginning of Chapter 9, Waste Treatment Ponds. Lecture Outline 9.6 Starting the Pond 1. Place one foot of water over bottom of pond before introducing wastewater 2. If possible, start pond during warmer part of year 3. Algae 4. pH 9.7 Daily Operation and Maintenance DO NOT NEGLECT A POND, DAILY OPERATIONAL AND MAINTENANCE DUTIES MUST BE PERFORMED 1. Scum control 2. Odor control 3. Weed and insect control 4. Levee maintenance 5. Headworks and screening 6. Operating hints 7. Abnormal operation 8. Batch operation	

Week 13	Hour 2 (Con'd)	Chapter: 9 Waste Treatment Ponds

Lesson Outline	Lecture Notes
9. Shutting down a pond 10. Operating strategy 9.8 Surface Aerators 1. To provide additional air for ponds during the night or during cold weather, or for overloaded ponds. 2. To provide a mechanical aeration device for ponds operated as an aerated lagoon. Aerated lagoons operate similar to an activated sludge aeration tank without returning any settled activated sludge 3. Purpose of aerator components (Refer to Table 9.2, 2nd Ed.) 9.9 Sampling and Analysis 9.90 Importance 1. DO, pH, temperature 2. Color of pond 9.91 Frequency and location of lab samples (Refer to Table 9.3, 2nd Ed. frequency and location of lab samples) 1. Grab samples 2. Composite samples	

Week 13	Hour 2 (Con'd)	Chapter: 9 Waste Treatment Ponds

Lesson Outline	Lecture Notes
9.92 Expected treatment efficiencies 9.10 Safety 1. Slippery surfaces 2. Ventilate enclosed headworks 3. Working from a boat 4. Electrical hazards 5. Application of pesticides or herbicides 6. Fence area and provide warning signs	

Week 13	Hour 3	Chapter: 9 Waste Treatment Ponds

Lesson Outline	Lecture Notes
Objectives: Refer to the objectives listed at the beginning of Chapter 9, Waste Treatment Ponds. Lecture Outline 9.11 Review of Plans and Specifications A careful review of the plans and specifications of a proposed pond can provide the operator an opportunity to suggest improvements and changes in design before construction which will allow the operator and the ponds to do a better job. Items to consider during review include: 1. Location a. Homes b. Wind directions 2. Chemistry of Wastes a. BOD b. Toxicants c. pH 3. Headworks and screening 4. Flow measuring devices 5. Inlet and outlet structures 6. Levees	

Lesson Outline	Lecture Notes
7. Pond depths 8. Fencing and signs 9. Surface aerators 10. Pond loading a. Detention time Detention time, days = $\frac{\text{Pond Volume, ac-ft}}{\text{Influent Rate, ac-ft/day}}$ b. Population loading No. of persons per acre = $\frac{\text{Population served, persons}}{\text{Area of Pond, ac.}}$ c. Hydraulic loading Inches per day = $\frac{\text{Inflow, ac-in per day}}{\text{Pond Area, ac.}}$ or Inches per day = $\frac{\text{Pond Depth, in.}}{\text{Detention time, days}}$ d. Organic loading Organic load, lbs BOD per day per acre = $\frac{\text{Flow, MGD} \times \text{BOD, mg/l} \times 8.34 \text{ lbs/gal}}{\text{Pond Area, ac.}}$ 11. Example calculations a. Pond area, acres b. Pond volume, ac-ft c. Loading parameters 1. Detention time	

Week 13 Hour 3 (Con'd) Chapter: 9 Waste Treatment Ponds	
Lesson Outline	**Lecture Notes**
2. Population loading 3. Hydraulic loading 4. Organic loading 9.12 Removal of Algae from Pond Effluents 1. Pond isolation 2. Water hyacinth culture	

Week 13 3-Hour Lab (Optional) **Chapter:** 9 Waste Treatment Ponds

Lesson Outline	Lecture Notes
Objective: Visit a waste treatment pond and observe or help (if possible) the operator operate and maintain the pond.	

CHAPTER 10

DISINFECTION AND CHLORINATION

Week 14	Hour 1	Chapter: 10 Disinfection and Chlorination

Lesson Outline	Lecture Notes
Objectives: Refer to the objectives listed at the beginning of Chapter 10, Disinfection and Chlorination. Assignment: Discussion and review questions at the end of each lesson and the objective test at the end of Chapter 10. NOTE: Material on dechlorination may be omitted if sufficient time is not available. Lecture Outline Glossary: Review new words 10.0 Need for disinfection 10.00 Effectiveness in micro-organism removal by various treatment processes (Refer to Fig. 28) 10.01 Disinfection 1. Difference between disinfection and sterilization 2. Public water supplies 3. Receiving waters for recreational uses 4. Shellfish growing areas 10.02 Reaction of chlorine in wastewater	

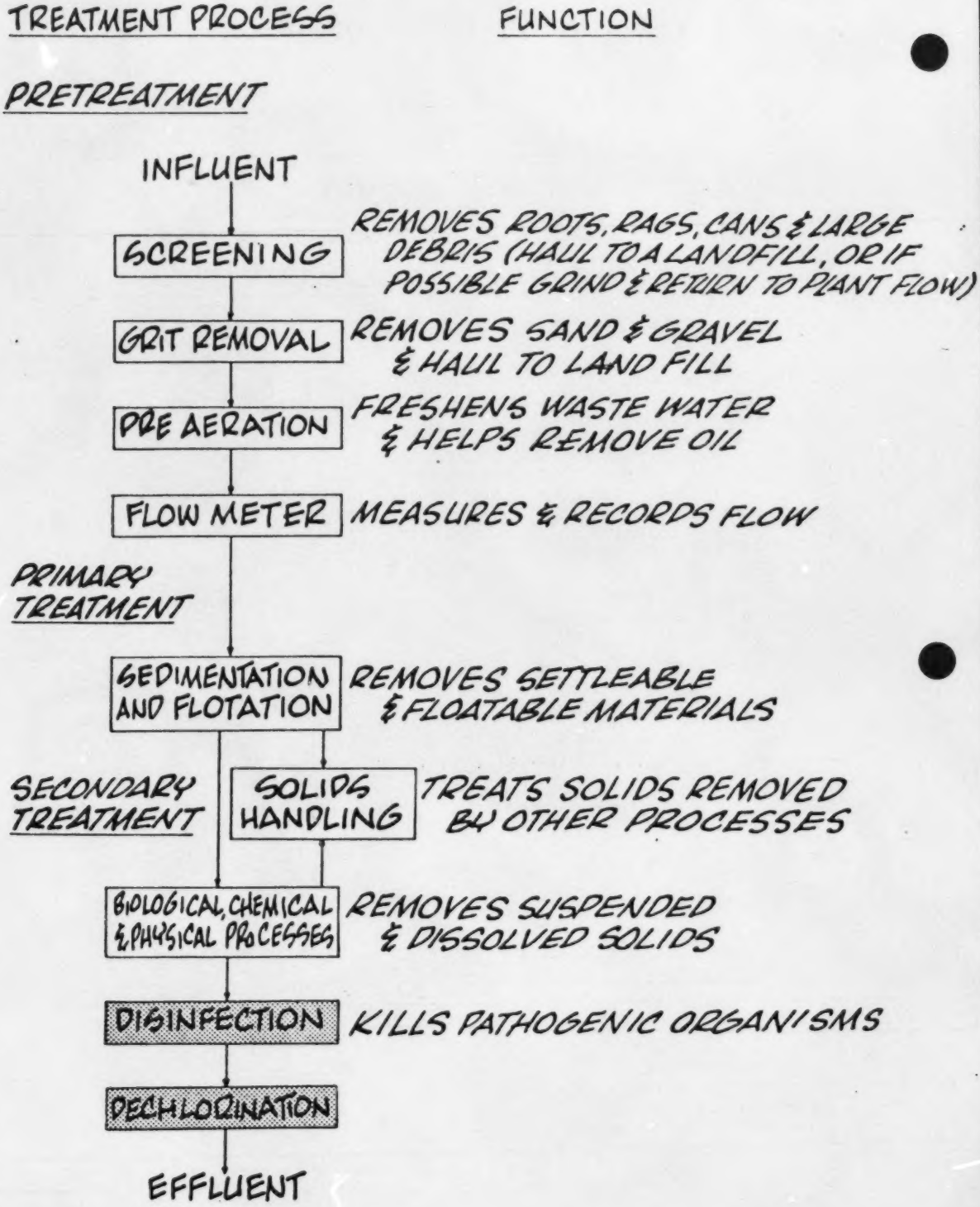

TREATMENT PROCESS
FUNCTION
PRETREATMENT
INFLUENT
SCREENING
REMOVES ROOTS, RAGS, CANS & LARGE DEBRIS (HAUL TO A LANDFILL, OR IF POSSIBLE GRIND & RETURN TO PLANT FLOW)
GRIT REMOVAL
REMOVES SAND & GRAVEL & HAUL TO LAND FILL
PRE AERATION
FRESHENS WASTE WATER & HELPS REMOVE OIL
FLOW METER
MEASURES & RECORDS FLOW
PRIMARY TREATMENT
SEDIMENTATION AND FLOTATION
REMOVES SETTLEABLE & FLOATABLE MATERIALS
SECONDARY TREATMENT
SOLIDS HANDLING
TREATS SOLIDS REMOVED BY OTHER PROCESSES
BIOLOGICAL, CHEMICAL & PHYSICAL PROCESSES
REMOVES SUSPENDED & DISSOLVED SOLIDS
DISINFECTION
KILLS PATHOGENIC ORGANISMS
DECHLORINATION
EFFLUENT

Fig. 28

Week 14 Hour 1 (Con'd) Chapter: 10
Disinfection and Chlorination

Lesson Outline	Lecture Notes
10.03 Reactions of chlorine solutions with impurities in wastewater 1. Inorganic reducing materials 2. Reaction with ammonia (NH_3) 10.04 Hypochlorination of wastewater 10.05 Factors influencing disinfection 1. Injection point 2. Design (shape) of contact chamber 3. Contact time 4. Effectiveness of upstream treatment processes 5. Temperature 6. Dose rate and type of chemical 7. pH 10.06 Chlorine requirements	

Week 14	Hour 2	Chapter: 10 Disinfection and Chlorination

Lesson Outline	Lecture Notes
Objectives: Refer to the objectives listed at the beginning of Chapter 10, Disinfection and Chlorination. Lecture Outline 10.1 Points of Chlorine Application (Refer to Fig. 29) 10.10 Collection system chlorination 10.11 Prechlorination 10.12 Plant chlorination 10.13 Post chlorination 10.2 Chlorination Process Control 10.20 Chlorinator control 1. Manual control 2. Start - stop control 3. Step-rate control 4. Time program control 5. Flow proportional control 6. Chlorine residual control 7. Compound loop control 10.21 Chlorination control nomogram 1. How to use nomogram 2. Work examples 10.22 Hypochlorinator feed rate control 10.23 Chlorine solution discharge	

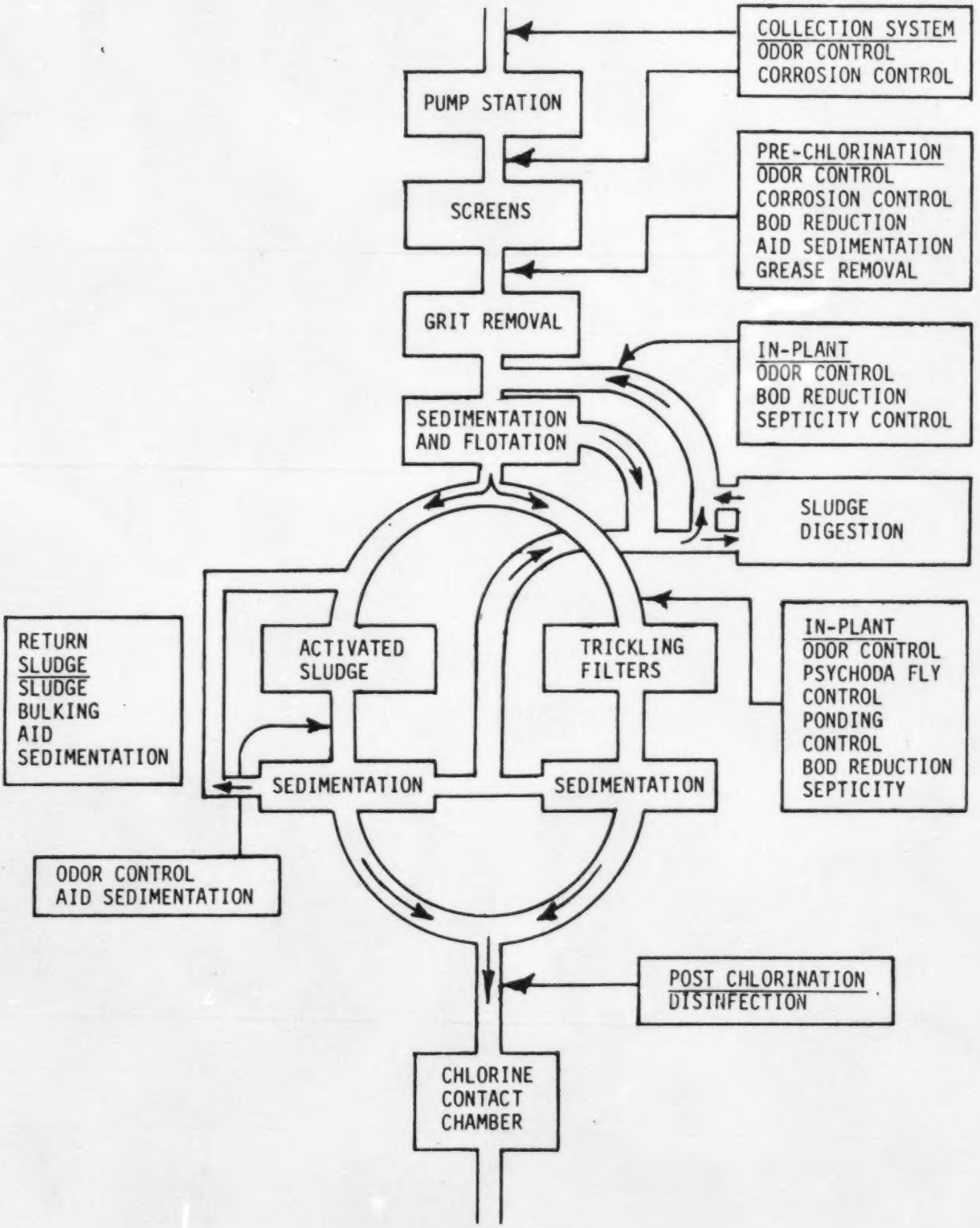


Fig. 29, Points of chlorine application

Lesson Outline	Lecture Notes
lines, diffusers, and mixing	
1. Solution discharge lines	
2. Chlorine solution diffusers	
3. Mixing	
10.24 Measurement of chlorine residual	
10.25 Start up of chlorinators	
1. Gas chlorinators	
2. Liquid chlorine chlorinators	
10.26 Normal and abnormal operation	
1. Container storage area	
2. Evaporators	
3. No chlorine gas flow to the chlorinator (cylinder empty or icing)	
4. Low chlorine residual	
10.27 Shut down of a chlorinator	
1. Short-term shut down	
2. Long-term shut down	
10.28 Operational strategy	
1. Disinfection	
2. Process control	
3. Odor control	
4. Dechlorination	

Week 14	Hour 2 (Con'd) Chapter: 10 Disinfection and Chlorination

Lesson Outline	Lecture Notes
5. Problems a. Run out of chlorine b. Failure of automatic control equipment c. Loss of injector vacuum d. Component failure 10.29 Chlorine Trouble-shooting Guide 1. Chlorine contact chamber 2. Chlorinator and evaporator 3. Chlorine supply system	

Week 14	Hour 3	Chapter: 10 Disinfection and Chlorination

Lesson Outline	Lecture Notes
Objectives: Refer to the objectives listed at the beginning of Chapter 10, Disinfection and Chlorination Lecture Outline 10.3 Chlorine Safety Program 1. Establish a safety program 2. Written rules 3. Periodic hands-on training using safety equipment 4. Establish emergency procedures for chlorine leaks and first aid 5. Establish a maintenance and calibration program for safety devices and equipment 10.30 Chlorine Hazards 10.31 Why chlorine must be handled with care 10.32 Protect yourself from chlorine 10.33 First aid measures 10.4 Chlorine Handling 10.40 Chlorine Containers 1. Cylinders 2. Ton tanks 3. Chlorine tank cars	

Week 14	Hour 3 (Con'd)	Chapter: 10 Disinfection and Chlorination

Lesson Outline	Lecture Notes
10.41 Removing chlorine from containers 1. Connections 2. Valves. Do not use wrenches longer than six inches to turn valves. 3. Ton tanks 10.42 Chlorine leaks 1. Before any new system is put into service 2. To find a chlorine leak 3. Equipment leak 4. Chlorine cylinder or container leak 5. Prolonged or unstoppable leak 6. Never put water on a chlorine leak 7. Leaks around valve stems 8. Valve discharge outlet leaks 9. Fusible plug and cylinder valve leaks	

Lesson Outline	Lecture Notes
10. Pin hole leaks 11. Do not ship leaking containers 12. Do not accept damaged or leaking containers 13. If a chlorine container develops a leak, be sure your supplier does not charge you for the unused chlorine. 14. Detection devices and alarm systems	

Week 14	3 - Hour Lab (Optional)	Chapter: 10 Disinfection and Chlorination

Lesson Outline	Lecture Notes
Objective: 1. Visit a wastewater or water treatment plant and observe or help (if possible) the operator operate and maintain a chlorinator. OR 2. Invite a representative from a chlorine manufacturer to discuss and demonstrate safe procedures for handling chlorine.	

Week 15	Hour 1	Chapter: 10 Disinfection and Chlorination

Lesson Outline	Lecture Notes
Objectives: Refer to the objectives listed at the beginning of Chapter 10, Disinfection and Chlorination. Assignment: Finish last week's assignment Lecture Outline 10.5 Chlorination Equipment and Maintenance. 10.50 Chlorinators 1. Purpose: Put chlorine gas in a solution for application to the wastewater. 2. Chlorinator components and purpose (Refer to Table 10.3, Second Edition) 10.51 Evaporators 10.52 Hypochlorinators 10.53 Installation and maintenance 10.54 Installation requirements 1. Piping, valves and mainfolds 2. Chlorinator injector water supply 10.6 Other Uses of Chlorine	

Week 15	Hour 1 (Con'd) Chapter: 10 Disinfection and Chlorination

Lesson Outline	Lecture Notes
10.60 Odor control 10.61 Protection of Structures 10.62 Aid to treatment 1. Sedimentation and grease removal 2. Trickling filters 3. Activated sludge 4. Reduction of BOD	

Week 15 Hour 2 Chapter:

Lesson Outline	Lecture Notes
Objective: Review for Exam III 1. Cover important material since last exam. 2. Emphasize purpose of processes, equipment and components. 3. Discuss start up, normal and abnormal operation, and shut down of processes and equipment. 4. Outline maintenance procedures. 5. Review safety hazards and safe procedures. 6. Identify important items that should be considered when reviewing plans and specifications. 7. Outline trouble-shooting procedures.	

Week 15	Hour 3	Chapter:

Lesson Outline	Lecture Notes
Objective: Exam III	

Week 15	3-Hour Lab (Optional)	Chapter: 10 Disinfection and Chlorination

Lesson Outline	Lecture Notes
Objective: Learn how to use safety equipment. 1. Self-contained breathing apparatus 2. Gas detection devices a. Toxic gases, hydrogen sulfide b. Explosive conditions (Lower Explosive Limit) c. Oxygen deficiency	

Week 16 Hour 1 Chapter:

Lesson Outline	Lecture Notes
Objectives: 1. Review results of Exam III and correct all mistakes and errors. 2. Identify areas for future review and students who need additional help.	

Week 16 Hour 2 and 3 Chapter:

Lesson Outline	Lecture Notes
Objectives: 1. Cover any material not covered to date. 2. Review for final exam.	

Week 16 3-Hour Lab (Optional) Chapter:

Lesson Outline	Lecture Notes
Suggest instructor select most appropriate lab activity for class.	

Week 17 Hour Chapter:	
Lesson Outline Objective: Final Exam.	Lecture Notes